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REFERENCES TO CAPILLARITY

TO THE END OF THE YEAR 1900

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Being CHAPTER VII of  
"A STUDY IN PHARMACY"

By John Uri Lloyd, Phr. M.

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The References collected and abstracted under the auspices of John Uri Lloyd

By Sigmund Waldbott, Ph. D.

Librarian of the Lloyd Library



# “REFERENCES TO CAPILLARITY”

About 1880, the undersigned became interested in capillary phenomena, especially the phenomenon of the pendent drop that becomes manifest when mixtures of a heavy liquid, as for example, chloroform, and a lighter, immiscible liquid of greater capillarity, for example, water, are shaken together in a vial and allowed to separate. This *pendent drop*,\* seemingly heretofore unobserved, invariably forms under these conditions and, a constant factor, always droops from the centre of the surface of the lighter liquid. Its study led to an interesting line of experimental investigations, which yet under consideration, involve the surface contact of immiscible liquids, and the meniscus that forms between them.

About 1890 considerable journalistic discussion arose concerning the field of the pharmacist's labors and the pharmacist's opportunities in recreative thought and experimental investigation. With a view to illustrating the fact that most entrancing opportunities are ever open in our own province, the afore-named striking phenomenon, apparently insignificant, that for years had led the author to much pleasurable research, was taken as a text.

But before venturing to introduce the subject of his investigations publicly, it became necessary to determine that the field had not been preoccupied. With this intent, a résumé of the literature on capillarity was attempted, and in 1894, under the title "A Study in Pharmacy," the first fascicle preliminary to its consideration was distributed to a select list of recipients presumed to be concerned in such studies.

It would not have been possible for the undersigned to have even thought of making this record of the special references to capillarity had it not been for the co-operation of Dr. Sigmund Waldbott, Librarian of the Lloyd Library, who, appreciating the necessity for thoroughness, with vigor and persistence, set about the work of correlating the literature on that subject. As the work progressed, it became evident that the field was much greater even than could possibly have been anticipated, many connecting lines, such as electrical phenomena and other phases of physics and chemistry, becoming involved. Extended time was thus found to be a necessity for searching and making a comprehensive consideration of the literature consulted, which in the aggregate proved to be enormous.

From 1894 to 1902, as fast as it was possible to complete them, fascicles of this research have been successively issued, the portion concerning capillary references bringing the work to the close of the nineteenth century. The result

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\*A term coined by the writer as being expressive and appropriate.



of it all is a failure to discover that any person has intruded on the special field the undersigned invaded in his experiments with the pendent drop and contact lines between liquids, which, however, owing to delays incident to this literary research, have been held in abeyance and are yet to be recorded.

It has been suggested, now that the references are completed, that the pages relative to capillarity be placed at the command of persons concerned in science, and it is with this object in view that this special section of "A Study in Pharmacy," is herein reproduced as Bulletin No. 4 of the Lloyd Library Series.

In closing, the undersigned wishes also to acknowledge his indebtedness to the Librarian of the Public Library of Cincinnati, Dr. N. D. C. Hodges, and his predecessor, the late Mr. A. W. Whelpley, for their many courtesies and attentions during the course of the research.

JOHN URI LLOYD.

CINCINNATI, MAY, 1902.

## CHAPTER VII.

### OUTLINE OF STUDY.

The word capillarity (from capillus, a hair,) originally applied to the phenomenon observed in a portion of liquid that rises above the common level, as water in a narrow glass tube, now embraces several sub-sections. Since brief reference only is made to this phenomenon in our pharmacal works, and as in none of them do we find citations that assist us in the study of this neglected section of pharmacy, before entering into a more detailed review of the subject embraced under the blanket term capillarity, it seems proper to present references to such connected literature as has been consulted in the production of this résumé. With this object, an endeavor will be made to begin with the earliest reference and end with the current year.

It should be borne in mind that the list is offered as a guide to the closer study of any one of the many ramifications of this vast subject. Although in some respects the list may be wanting here and there in completeness; yet it seems improbable that many conspicuous workers in capillarity have been overlooked. While it is impractical to present a complete detail synopsis of each paper, an attempt has usually been made with each citation when the title is not expressive to give a brief idea of the subjects embraced therein. The heavier type gives the full title of the work, the nonpareil type following gives a synopsis of its contents. Moreover, an attempt will be made at the end of the list, to embrace in a concise summarizing outline, the main data furnished by these references. The list is recorded in chronological order, instead of being classified by subjects, or alphabetically by authors, and in subsequent groupings references will usually be made to it by these list numbers.

# LITERATURE ON CAPILLARITY.

1. 1452-1519. LEONARDO DA VINCI. See *Pogg. Ann.* Vol. 101. p. 551. [1857.]

Poggendorf gives the following historical points on capillarity:

Libri, *Hist. des sciences math. en Italie*. T. III, p. 54, states that descriptions of experiments relating to capillary phenomena are recorded in the Manuscripts of Leonardo da Vinci, which are deposited in Paris; thus this celebrated and versatile painter must be regarded as having first described capillary phenomena.

Nelli, *Saggio di storia letteraria fiorentina*, p. 92, and

Lalande, *Dissertation*, 1770, (see No. 29,) ascribe the discovery of capillary phenomena to Nicola Aggiunti, who died in 1635.

2. 1660 (thereabouts.) FABRI, HONORATO. See Buelffinger. No. 19. (*Colleg. Curios. P. I. Tent. VIII*, p. 44, 45.)

Records some observations pertaining to capillarity, e. g., that water rises higher in narrower than in wider tubes, and higher in moistened than in dry ones, and ascribes the cause of the ascent to the pressure of air, which can exert itself more freely on the surface of the outside water, as it is more abundant there than at the water surface within the tube.

3. 1667. MONTANARI, GEMINIANO. *Pensieri fisico matematici*. Bologna 1667.

C. Brunner, *Pogg. Ann.*, 70, 489, (1847) attributes to him the merit of having given the theory of capillarity its first scientific foundation; some quotations from his work are recorded.

Also Frankenheim gives Montanari due and ample credit in his "Cohaesionslehre." (See Frankenheim, *Pogg. Ann.*, 72, 178.)

4. 1676. BOYLE, ROBERT. New experiments on the superficial figures of fluids, especially of liquors contiguous to other liquors, and their respective powers. *Phil. Trans.*, No. 131, p. 775, or *Phil. Trans. Abridged*. (J. Lowthorp,) 1658-1700. Vol. I, p. 525-534, or *Phil. Trans. Abridged*, (Hutton, Shaw, Pearson,) 1672-1683, Vol. I, p. 362, or Boyle, *Philos. Works*, (Peter Shaw,) Lond. 1738, Vol. I, p. 316 and 388.

Relative to the changes in the shape of the common curvature between liquids in contact with each other, e. g., some Essential Oils, Water, Deliquated Salt of Tartar, Alcohol, Mercury. He also studied the common surface in its behavior towards incidental light.

5. 1683. BERNOULLI, JAC. *De gravitate aetheris* See Buelffinger No. 19.

The air presses on the tubular surface of the water with less force than upon the same area of the surface in the outside vessel, (see Fabri, No. 2.) The author's theory is that the particles of the air occupy space; thus if a row consisting of a definite number, say 7 particles, are just sufficient to fill out the diameter of the tube, and if 8 particles are about to enter its upper orifice, the two extreme ones are barred by the upper edge of the tube, and but six will be admitted. On an equal area of the outside surface the 7 particles can exert their force in opposition, thus exceeding the inside pressure. The narrower the tube, the more pronounced is the exclusion of the air particles.

6. 1686. BORELLI, G. A. *De motionibus a gravitate pendentibus*. Lugd. Bat. 1686. See Buelffinger. No. 19.

Borelli explains the capillary ascent of water by assuming that with the external water there is an excess of energy over that inside the tube. The great inner surface of the latter causes an attractive force which renders the entering water less heavy, as it were, than it is outside. The rise will cease when the inside weight of the water counterbalances the outside pressure.



7. 1700 (about.) HUYGHENS. An attempt to render the cause of that odd phenomenon of the quicksilver remaining suspended far above the usual height in the Torricellian experiment. *Phil. Trans.* No. 86, p. 5027. Or *Phil. Trans. Abridged*, (J. Lowthorp.) 1658-1700. Vol. II, p. 23.

Claims that there exists a pressure in addition to that of air, caused by the existence of an all-penetrating subtle matter which acts on the lower end of the mercurial column with its full force, but not so on the upper, as the sides of the glass still offer some resistance to the act of penetration. A shock suffices to drop that column to its usual height of 27 inches. Supposed proof of this additional pressure is offered by experiments with ground plates which adhere also in vacuo, and that too even though the lower plate has another weight added.

8. 1705. CARRE, LOUIS. *Mém. Acad. Sc. Paris.* 1705, p. 317. See Buellfinger No. 19. Also Weitbrecht No. 24.

Proves the adhesion of water for glass by experiments with tallow-lined glass tubes.

Among other conclusions he also states that the length of the capillary tube does not influence the height to which water rises in its cavity.

9. 1709. HAUKSBEE, FR. *Physico-Mechanical experiments.* London 1709.

10. 1703-1712. HAUKSBEE, F. An experiment made at Gresham College, showing that the seemingly spontaneous ascent of water in small tubes, open at both ends, is the same in vacuo as in the open air. *Phil. Trans.* No. 305, p. 2223, or *Phil. Trans. Abridged*, (Hutton, Shaw, Pearson.) Vol. V, p. 289.

Beside the result indicated in the title, Hanksbee shows that in removing capillary tubes from the fluid, as much will remain suspended in the tubes as rose above the surface of the fluid when dipped into it. He also claims that in order to make a capillary syphon run, the orifice of the longer leg must be at least so far below the surface of the stagnant water, as the water would rise by capillarity in the same tube.

11. 1703-1712. HAUKSBEE, F. Several experiments on the seeming spontaneous ascent of water. *Phil. Trans.*, No. 319 p. 258, or *Phil. Trans. Abridged* (Hutton, Shaw, Pearson.) 1703-1712. Vol. V, p. 464.

Describes the ascent of a tinged fluid between 2 glass plates separated by thin layers of paper, in air and in vacuo; fluids rise in thick tubes to same height as in thin tubes of equal bore. The increased power of attraction in narrow tubes is due to the augmented disproportion between the inner area and the cavity. Rise of water studied in a long and wide tube tightly filled with ashes.

First observed the rise of water between two parallel planes of glass or other substances.

12. 1703-1712. HAUKSBEE, FR. An experiment, showing the direction of a drop of oil of oranges between two glass planes towards any side of them that is nearest pressed together. *Phil. Trans.*, No. 332, p. 395, or *Phil. Trans. Abridged*, (Hutton, Shaw, Pearson.) 1703-1712. Vol. V, p. 659.

The drop moves towards the side of least distance, with increasing velocity. The latter fact explained by the augmentation of the contact surfaces.

13. 1703-1712. HAUKSBEE, F. An experiment concerning the angle required to suspend a drop of oil of oranges at certain stations between two glass planes, placed in the form of a wedge.

The drop has a tendency to move towards the convergent side of the wedge, but is arrested in its motion when the plate system is raised by a certain angle. Then gravitation counterbalances capillary motion. Numerical relations are given between angle of elevation and distance of drop from center of plates.

14. 1712. TAYLOR, BROOK. Concerning the ascent of water between two glass planes. *Phil. Trans.*, 1712, No. 336, p. 538, or *Phil. Trans. Abridged*, (Hutton, Shaw, Pearson,) 1703-1712, Vol. V, p. 706, or *Phil. Trans. Abridged*, (Henry Jones,) 1700-1720, Vol. IV, p. 423.

Was the first to recognize the fact that water which rises between vertical glass plates forming an angle, presents the outlines of an hyperbola. (See No. 15.)

15. 1712. HAUKSBEE, FR. On the ascent of water between two glass planes. *Phil. Trans.*, No. 336, p. 539, or *Phil. Trans. Abridged*, (Hutton, Shaw, Pearson,) 1703-1712, Vol. V, p. 707.

The capillary rise of water between vertical convergent glass planes takes place in the outlines of an hyperbola. Observed the phenomenon almost simultaneously with Brook Taylor, but gives the latter the credit of priority.

16. 1700-1720. JURIN, J. Dr. The cause of the ascent and suspension of water in capillary tubes. *Phil. Trans.*, No. 355, p. 739, or *Phil. Trans.*, (Henry Jones,) 1700-1720, Vol. IV, p. 423.

Devising some interesting experiments to prove the assertion that rise and suspension of water in capillary tubes is due to the attraction of the interior annular part of the tube which is above and contiguous to the enclosed water surface. The height of ascent in different tubes is in inverse ratio to the diameters of the tubes. (Jurin's law.)

Jurin's explanation was also adopted by R. Boyle, see "Works" Vol. I, p. 447; the latter there records the ascent of water equal to five inches in very thin glass tubes.

17. 1700-1720. JURIN, J. The action of glass tubes upon water and quicksilver. *Phil. Trans.*, No. 363 p. 1083, or *Phil. Trans.*, (Henry Jones,) 1700-1720, Vol. IV, p. 428-435.

By ingenious experiments he refutes certain objections that had been made to his theory. (See No. 16.) Furthermore he ascribes the different behavior between water and mercury in capillary glass tubes to the preponderance of either cohesion or adhesion in each particular case; with water and glass the attraction is greater than that between the water particles; in the case of mercury, the cohesion of its particles is greater than their adhesion to the glass.

18. 1720-33. TAYLOR, BROOK. Measuring the cohesion of water by means of fir-board. *Phil. Trans. Abridged*, (John Eames, J. Martyn.) Vol. II, p. 255.

By means of a balance it was found that 50 grains in weight were necessary to separate each square inch of soaked and well-balanced fir-wood from the surface of water; the force is in proportion to the surface. At the moment of separation the distance of the lower plane of the fir-board from the level of the water was 16-100 of an inch.

19. 1727. BUELFINGER. De Tubulis Capillaribus Dissertatio Experimentalis. *Comment. Acad. Petropol.* T. II, p. 233-287.

Giving a critical review of preceding literature on Capillarity, viz: By Fabri, Boyle, Carre, J. Bernoulli, Vossius, Borelli, Jurin and others.

20. 1728. JURIN, J. Disquisitiones physicae de Tubulis capillaribus. With notes by G. B. Buelffinger. *Comment. Acad. Petropol.* T. III, p. 281-292.

Rejoinder to Buelffinger, the latter, in his notes, acquiescing in Jurin's views.

21. 1729. MUSSCHENBROECK. *Dissertatio de tubis capillaribus vitreis.* Lugd. Bat. 1729.

Muschenbroeck and other physicists conclude from experiments that the length of capillary glass tubes influences the ascent of water therein. (See No. 59.)

22. 1730. NEWTON, SIR I. *Opticks*. 4th Edition London. 1730.  
31st query.

The capillary phenomena observed by Hauksbee, and the observation made by Huyghens of the quicksilver remaining suspended in a barometric tube to the height of 70 inches are adduced as examples to illustrate the various forms of attraction.

23. 1732. SUSSMILCH, I. P. *De cohaesione et attractione corporum*.  
Jenae, 1732.

24. 1736. WEITBRECHT, J. *Tent. theor. qua ascensus aquae in tubis capill. explicatur*. *Comment. Acad. Petrop.* T. VIII, p. 261-309.

Coincides with Jurin's views in explaining the cause of water remaining suspended in capillary tubes. (See No. 16.)

As to the phenomenon of *rise*, he inductively shows, that the ascent is the result of the following contending forces:

1)—Attraction between glass and water, causing an aqueous film to form inside, equal in thickness to the diameter of the sphere of attraction.

2)—Cohesion between film particles and remaining water particles, causing aqueous lamels to enter the tube.

3)—Cohesion between the water particles themselves, causing the water to follow the entering lamels, finally resulting in an aqueous "core," connected with the "film" through force No. 2.

4)—Weight of the column.

The rise ends when these forces are in equilibrium.

25. 1737. WEITBRECHT, J. *Explicatio difficiliorum experimentorum circa ascensum aquae in tubos capillares*. *Comment. Acad. Petrop.* T. IX, p. 275-309.

Accounts for capillary phenomena in cylindrical and conical tubes and capillary syphons of various shapes.

Applies his theories to similar observations described by Jurin (see No. 17.) and Musschenbroeck. (see No. 21.)

26. 1740. GELLERT, C. E. a) *De phaenomenis plumbi fusi in tubis capillaribus*. b) *De tubis capillaribus prismaticis*. *Comment. Acad. Petrop.* T. XI, p. 243a, 252b.

a)—Experiments with melted lead demonstrate that it has the capillary properties of mercury. With both curved and straight tubes of glass or clay of the same bore, the melted lead is depressed to the same depth below the surface.

b) With tubes of prismatic form it is shown that the depression is in reverse ratio to the square root of the cross section of the tube.

27. 1751. SEGNER. *Comment. Societat. Reg. Gotting.* I. 301. 1751.

First made reference to the surface tension of liquids. (*Encycl. Brit.*)

28. 1756. LEIDENFROST. *De aquae communis nonnullis qualitatibus tractatus*. Duisburg 1756.

Observed the contractile property of soap bubbles, but failed to ascribe it to a generally existing force. (*Encycl. Br.*)

29. 1770. LALANDE. *Dissertation sur la cause de l'élévation des liqueurs dans les tubes capillaires*. Paris, 1770.

Referred to by several authors, (see Leslie and C. Wolf.)

30. 1773. FUNCCIUS, C. B. *Commentat. II. De ascensu fluidorum in tubis capillaribus*. Lipsiae 1773.

Funccius is of the opinion that capillary attraction manifests itself only at the place of immediate contact, thus the length of the tube should have no influence on the height of rise. (See No. 50.)



- 31.** 1774. FRANKLIN, BENJ. Stilling of waves by means of oil.  
*Phil. Trans.*, 1774, p. 445.

Credit given to Pliny for first mentioning the phenomenon. Seamen are quite familiar with it. Franklin calls attention to the amazing swiftness with which a drop of oil spreads on water. From his experience he concludes that oil has a decided tendency to calm the water, but points to some limits of the action.

- 32.** 1780. MORVEAU. *Chemisch-physische Schriften*. Berlin, 1789, p. 334-367.

- 33.** 1784. ACHARD. *Sammlung physikalischer Abhandlungen*. Berlin, 1784, p. 91.

- 33a.** 1786. DUBUAT. *Traité d'Hydraulique*. (1786.)

Was the first to experiment on the flow of liquids through capillary tubes.

- 34.** 1787. MONGE. *Mém. de l'Acad. des Sciences*. 1787, p. 506.

The adherence of the particles of a fluid becomes manifest only at the surface, producing there an elastic membrane whose tension is equal in all directions and may be calculated by mathematical analysis from the primary attraction between any two adjoining particles. This principle is applied to the explanation of the apparent attractions and repulsions between bodies floating on a liquid. (*Encycl. Brit.*)

- 35.** 1790. ACHARD. *Expériences sur l'adhésion des corps aux liquides*.  
*Ann. Chim.* (1) Vol. 7, p. 31-33.

The cohesion of water lessens with rising temperature. Measurements were made by means of counterbalanced plates of glass.

- 36.** 1790. MORVEAU, G. *Ann. Chim.* (1) Vol. 7, p. 32.

Records in figures the force of adhesion between mercury and circular metal disks of one inch diameter after the method of Dr. Taylor. (See Nos. 18 and 35.)  
e. g.—Adhesion of mercury for gold—446 grains.

for iron—115 grains.

Concludes that the adhesion between solids and liquids is in proportion to their mutual solubility.

- 37.** 1796. HUTH. *Adhaesion von Wasser fuer verschiedene Holzarten*.  
*Gren's neues Journal der Physik*. Vol. 3, p. 299.

It is claimed that there are some differences noticeable in the adhesion of water for different kinds of wood: the adhesion of water seems to be strongest for pine-wood and white beech. The average amount is about one pound to the square Rhenish foot.

- 38.** 1797. CARRADORI. *Attraction schwimmender Koerper*. Communicated by Murhard. *Gren's neues Journal der Physik*. Vol. 4, p. 78.

Small solid bodies floating on a liquid, like the particles of sawdust, attract one another, not by virtue of an inherent attractive force but by the action of the cavity the water forms around them.

Oil bodies have a tendency to expand rapidly on water, especially milk, and the juice of *Tithymalis* and other plants of the order *Euphorbiaceæ*.

- 39.** 1797. MURHARD. *Betrachtung ueber die Schwierigkeit, die bei der Art stattfindet, wie die Newtonianer die Cohæsion der Koerper und die andern dahin gehoerenden Phaenomena erklaeren*. *Gren's neues Journal der Physik*. Vol. 4, p. 83-92.

As the force of cohesion between the particles decreases very rapidly with the distance, some apply to this force the law of the *cube* of the distance. But Murhard endeavors to show that the law of gravitation which speaks of the *square* of distance, is sufficient to explain the case of cohesion.

40. 1797. PREVOST, BEN. Sur les émanations des corps odorants. *Ann. Chim.* (1) Vol. 21, p. 254.

Odoriferous bottles when in contact with water, produce visible effects thereon: 1) They rapidly move about when thrown on its surface. (like camphor on water, first observed by Romieu.) 2) They repel a thin film of water, which then stays in a circle around the disturbing element. According to Prevost, these phenomena are due to the reaction of the vapors emitted. As "non-odoriferous" bodies, when warm, produce the same effects, they are also said to emanate vapors, which are however imperceptible to man, but often perceptible to animals, for example, dogs. Suggests the construction of an odoroscope to render odors visible.

41. 1797. VENTURI, J. B. Précis de quelques expériences sur la section que des cylindres de camphre éprouvent à la surface de l'eau, et réflexions sur les mouvements qui accompagnent cette section. *Ann. Chim.* (1) Vol. 21, p. 262-275.

Relates and explains the fact that water touching the middle part of a vertical column of camphor will produce within 24 hours a deep incision on this substance; the movements of oily bodies on water are explained on the principle of reaction, likewise the motion of a drop of water on a red hot iron plate, also the strange motions of the network of the fungus Tremella.

42. 1797. PREVOST, BEN. Sur les émanations des corps odorants. *Ann. Chim.* (1) Vol. 24, p. 31-56.

Continuation of No. 40. Substances that are easily volatile, like ether, and camphor, also impart motion to floating bodies when merely approaching the water.

43. 1799. GUYTON. Adhaerenz zwischen Platin und Quecksilber. *Gilb. Ann.*, Vol. 1, p. 572. From *Ann. Chim.*, 1798, p. 1-2.

A platinum dish 2.71 c. m. in diameter in contact with mercury for two days, as the time of contact increased required increasing weights to separate it from the mercury.

|                           |        |         |
|---------------------------|--------|---------|
| 1st observation required, | 109.   | grains. |
| 2nd       "       "       | 146.2  | "       |
| 3rd       "       "       | 282.25 | "       |

Under like conditions:—Platinum required 282.25 grains.

|                  |      |   |
|------------------|------|---|
| Bismuth       "  | 372. | " |
| Zinc           " | 204. | " |

44. 1799. HASSENFRATZ. Ueber den bisher noch nicht beachteten Einfluss der Adhaerenz auf die Bestimmung des spec. Gew. fester Koerper. Reported by Gilbert. *Gilb. Ann.*, Vol. 1, p. 396. From *Ann. Chim.*, Vol. 1, p. 188.

Hassenfratz claims to have proved by experiments that in taking spec. gravities by means of an areometer, this instrument indicates less than is shown by the spec. gravity bottle. He found the sp. gr. of oil taken by the areometer, 0.9165 and by the gravity bottle 0.9183, and endeavors to sustain his observation by demonstrating that a substance, say glass, after being powdered has a smaller spec. grav. than before. He claims that the adherence of air to the particles of glass does not sufficiently account for diminution of specific gravity, and ascribes this phenomenon to the adhesion of the liquid to the glass, which force increases with the mutually increasing surfaces.

45. 1799. ARNIM, L. A. von. Note to the paper of Mr. Hassenfratz. *Gilb. Ann.*, Vol. 1, p. 423.

Arnim states that Hauksbee in his works (see No. 9, French ed.) explicitly describes observations similar to those of Hassenfratz, (see No. 44.) When weighing in water, two pieces of copper of equal absolute weight, but of greatly different surfaces, the thin piece lost two grains more than the thicker one. As a consequence the spec. gravity of the thinner would be less. Similar observations were made with glass, in bulk and powdered. Finally Hauksbee says: "This phenomenon must be attributed to the same cause that sustains liquids in capillary tubes—attraction."

46. 1799. HERMBST.EDT and BERTIER. Attractionsversuche. *Gilb. Ann.* Vol. 2, p. 63.

a) A plate of glass, brass or marble, suspended from one end of the beam of a balance, and being in perfect equilibrium is attracted downward by a surface of mercury as soon as they approach within a distance of  $1\frac{1}{2}$  mm. of each other.

b) Bertier. *Hist. Ac. d. Sc. d. Par.*, 1751, p. 56, demonstrates how different bodies each suspended from a hair are attracted by other bodies held near to them.

47. 1799. BARRUEL. Sur l'élasticité. *Ann Chim.* (1) Vol. 33, p. 100-109 or *Tilloch's Mag.*, Vol. VI, p. 51-65. (1800)

Molecules of bodies are assumed to be surrounded by heat atmospheres which tend to counteract the coherence of the molecules. According to the relative magnitude of both forces, distinction is made between brittle and flexible bodies; the latter class is divided into ductile, soft and elastic bodies.

Liquids are ductile (because the molecules are mobile) and elastic at the same time, (because they transmit sound and rebound upon themselves.)

48. 1800. SCHMIDT, G. G. Einige Bemerkungen und Versuche ueber die vom Buerger Hassenfratz erregten Zweifel gegen die Richtigkeit der gewoehnlichen hydrostatischen Bestimmung des specifischen Gewichtes fester und fluessiger Koerper. *Gilb. Ann.*, Vol. 4, p. 194. (See No. 44.)

By repeating the experiments of Hassenfratz with tin foil, he found the specific gravity different under different circumstances. He comes to the conclusion that the tenacity or inertia of the molecules influences the determination of the specific gravity when made by means of the areometer.

Schmidt found that with an improved Fahrenheit areometer, good results were obtainable.

|                                        |         |                          |         |
|----------------------------------------|---------|--------------------------|---------|
| Providence Oil with the areometer gave | 0.9235, | with spec. grav. bottle, | 0.9202. |
| Alcohol                                | "       | "                        | 0.8135, |
|                                        | "       | "                        | "       |
|                                        | 0.8135, | "                        | 0.8135. |

49. 1800. COULOMB. Expériences destinées à déterminer la cohérence des fluides et les lois de leur résistance, dans les mouvements très lents. *Mém de l'Institut.*, 1800, Vol. III, p. 246-305.

50. 1800. ARNIM, L. A. Some experiments on the rise of water in capillary tubes. *Gilb. Ann.*, Vol. 4, p. 369.

Contrary to the experience of Weithrecht, and in conformity with that of Muschenbroeck, Arnim arrives at the conclusion supported by experiments, that the length of the capillary tubes has a decided influence upon the height of rise. The glass tube was shortened by breaking off pieces in succession.

51. 1800. GERSTNER. Versuche ueber die Fluessigkeit des Wassers bei verschiedenen Temperaturen. *Gilb. Annal.*, Vol. 5, p. 160-183.

Gives tabulated results of experiments carried on in order to determine, at different temperatures, the comparative velocity of water running through tubes of equal lengths and equal bore, and by observing the time required for known quantities of water to run out. He concludes that

1) The heat influences the motion of water considerably; e. g., the same quantity of water that runs out of a certain tube in 35 minutes, at  $30^{\circ}$  R., requires 76 minutes at the temperature of  $4^{\circ}$  R.

2) The changes in velocity are more pronounced in narrow than in wide tubes.

3) These changes do not take place in proportion to the heat, but have a maximum.

However there are some anomalous results.

52. 1800. CARRADORI, Dr. Sur l'adhésion ou attraction de superficie. Note de Guyton à ce sujet. *Ann. Chim.* (1) Vol. 34, p. 195-199.

Contrary to Morveau's view, adhesion is not the result of chemical affinity, nor can it be brought into any relation to it, because the fatty oils, that indeed have no affinity for water, have an adhesion to its surface, since they spread on the surface of water so rapidly.



- 53.** 1800. CARRADORI, Dr. Sur l'adhésion ou attraction de superficie. Translated by Toliard. *Ann. Chim.*, (1) Vol. 35, p. 87. Also see *Gilb. Ann.*, Vol. 12, p. 108, (1803).

Carradori observed that the juice of Euphorbia (tithymale) which will spread on water rapidly (see No. 38,) does not spread on alcohol, or vinegar. He further observed that certain oils that cover the surface of water may be displaced by other substances that have a greater surface attraction for water than the oils. He gives the following order of displacing power, where each following substance displaces any one preceding from the surface of water. Fixed oils, flour of cereals and leguminous plants, volatile oils, milky juice of plants, especially tithymale.

- 54.** 1800. CARRADORI, Dr. Sur les expériences du cit. Prevost de Genève sur la force expansible des émanations odoriférantes, et du cit. Venturi de Modène sur les mouvements du Camphre sur l'eau. (Translated by Van Mons.) *Ann. Chim.*, (1) Vol. 37, p. 38. See also *Gilb. Ann.*, Vol. 24, p. 147, (1806).

Contradicts the assertion of Prevost, (see No. 40.) that the recession of the water is due to the repelling power of the vapors emanating violently from the camphor; the reason which Carradori gives, is because the camphor has a greater attraction for the plate than water. He credits Venturi with the same view.

- 55.** 1802. PREVOST, BEN. Sur les mouvements spontanés de diverses substances à l'approche ou au contact les unes des autres. *Ann. Chim.*, (1) Vol. 40, p. 1-32. See also *Gilb. Ann.*, Vol. 24, p. 158, (1806).

Experiments are continued to prove that odoriferous substances impart motions to even heavy bodies floating on water, even though the odoriferous substance may not be in immediate contact with the water. Gives a list of substances, of which each following is displaced by any one preceding, when spread on a clean porcelain dish; from that list we mention here ether, alcohol, peppermint oil, oil of bergamot, fatty oils, pure water, ferrous sulfate, copper sulfate, sodium chlorid, ammonium chlorid.

- 56.** 1802. LESLIE, JOHN. On capillary attraction. *Phil. Mag.* (1) Vol. 14, p. 193.

A drop of water placed upon the under surface of a horizontal plate of glass, spreads upon the latter, forming a thin film. Similarly a drop will partly spread upward when the plate is held vertical. By virtue of such attraction the ascent of water in capillary tubes takes place.

Treating then of various topics bearing on capillarity, Leslie points out that a systematic observation of the capillary rise of different solutions, may prove a useful means to identify them, especially he suggests the construction of a capillary hydrometer for weak alcoholic liquors.

- 57.** 1803. DRAPARNAUD. Sur les mouvements que certains fluides reçoivent par le contact d'autres fluides. *Ann. Chim.*, (1) Vol. 47, p. 303. See also *Gilb. Ann.*, Vol. 24, p. 130, (1806).

Observations regarding the displacement of certain liquids by others in a porcelain dish. Alcohol displaces water. Alcohol displaces olive oil. Orange oil displaces water, but not as strongly as does alcohol. Alcohol displaces ammonia. According to Draparnaud's explanation, there is a repelling power between the liquids that displace each other, while Carradori (see No. 54,) asserts that this behavior of the liquids is determined by the difference in their attraction for the surface of the dish.

- 58.** 1803. HÆLLSTRÆM. Berechnung der mit einer Nadel gehobenen Wassercurve. *Gilb. Ann.*, Vol. 12, p. 625.

Finds the curve to be a catenarian line for which he gives an equation.

- 59.** 1803. HÆLLSTRØM. Ob das Wasser in laengeren Haarroehrchen hoeher aufsteige als in kuerzern. *Gilb. Ann.*, Vol. 14, p. 425-432.

When sucking out the water from the tubes before every new trial, as supposedly was done by Mussehenbroek. (see No. 21.) and Arnim (see No. 50), Hællstrøm obtained conflicting results, but when avoiding it, he obtained the same height of rise whether in long or small tubes. Same conclusion was arrived at by Weitbrecht. (see No. 25.)

- 60.** 1804. BENZENBERG. Gesetz der Cohæsion, ob es von dem der Gravitation verschieden ist, und Kritik der Murhard'schen Gruende. *Gilb. Ann.*, Vol. 16, p. 76.

It is shown by calculation that Newton's law of gravitation sufficiently accounts for the magnitude of the cohesive force, if we only presume the attracting particles to be exceedingly small, and especially take into consideration subdivisions of their minute distances. A table is given from which it is seen, at a glance, how immensely the attractive force increases when two particles approach each other step by step from the distance of an inch down to contact, even though the force of attraction merely obeys Newton's laws of the square of the distance.

Assuming, for instance, such small distances as 36,000 billionth of an inch, and the law of gravitation prevailing, the power necessary to separate two particles, would be the same as the attractive force existing between Venus and Earth equal to 7000 billions of centners.

- 61.** 1804. CARRADORI. Réponses aux objections du cit. Prevost. *Ann. Chim.*, (1) Vol. 48, p. 197.

He reviews Prevost's experiments on the motion of tinfoil on water caused by ether, and other similar experiments. (See No. 42.) Maintains that even in the case of a vapor causing such a motion, this is due not to a repulsion by an elastic fluid, but simply to a surface attraction between the water and the vapors.

- 62.** 1804. CARRADORI. Expériences et réflexions sur les apparentes répulsions entre quelques fluides, observées par Draparnaud. *Ann. Chim.*, (1) Vol. 51, p. 217. See also *Gilb. Ann.*, Vol. 24, p. 134, (1806).

Maintains the same point towards Draparnaud as towards Prevost, that e. g., alcohol displaces water on a porcelain dish, because of its greater attraction for the dish. Draparnaud claims that alcohol repels the water, forming thereby a continuous emission of alcohol particles towards the water finally resulting in its displacement.

- 63.** 1805. YOUNG, THOMAS. Essay on the cohesion of fluids. *Phil. Mag.*, Vol. 1805, p. 65.

Gives here the first complete theory of capillarity, basing it on two axioms:

- 1) The existence of a surface tension, equal in all directions.
- 2) The existence of a definite angle of contact appropriate to every combination of a fluid with a solid; when the fluid perfectly wets the solid, the angle is evanescent; for clean mercury and glass it is about 140°.

Thos. Young also shows how the existence of an equable surface tension may be deduced from the assumption that the equilibrium of the particles of a liquid is the result of two contending forces, one repulsive, and another cohesive. (Compare Barruel No. 47.) The essay covers such phases of capillarity as rise of liquids in tubes and between plates, relation between size of drops and height of rise, behavior of mercury, etc.

- 64.** 1805. LAPLACE. Sur l'action capillaire, et Supplément à la théorie de l'action capillaire. *Mécanique céleste*, T. IV, Supplément au X<sup>me</sup> livre.

(See Nos. 71, 76 and 77.)

- 65.** 1806. DISPAN. Sur la prétendue attraction de surface entre l'huile et l'eau. *Ann. Chim.*, (1) Vol. 57, p. 14-18. See also *Gilb. Ann.*, Vol. 24, p. 184-188.

Dispan says there is no mutual attraction between oil and water; the particles of the oil are mobile; the reaction of the water forces the drop falling upon it to expand; the outer thin circle experiences friction and finally the cohesion of the oil manifests itself and the oil gathers into a number of smaller drops. The second drop does not spread, because there is too much of an obstacle in its way; however, after a small amount of oil has become diffused, it allows succeeding drops to spread, and so on increasingly.

66. 1806. LINK, H. F. Ueber die Adhaesion tropfbarer Koerper mit einander. *Gilb. Ann.*, Vol. 24, p. 121-128.

Repeating and enlarging upon the experiments of Carradori and others, Link comes to the conclusion that the phenomena of surface attraction, contrary to Carradori's opinion, (see No. 54,) are dependent to a certain degree on chemical affinity. In support of his view, Link adduces the fact that sulfuric acid and alcohol, characterized by their marked affinity for water, repel all oils and resins from the surface of the latter. (See No. 53.)

67. 1806. GILBERT. Einige Streitschriften ueber die Flaechenanziehung (Adhaesion) der Fluessigkeiten unter sich und mit festen Koerpern. *Gilb. Ann.*, Vol. 24, p. 129-188.

Gives a critical review of the polemic papers of Prevost, Venturi, Carradori, Draparnaud and Dispan. (See Nos. 40, 41, 42, 52, 53, 54, 55, 57, 61, 62 and 65.)

68. 1807. YOUNG, THOMAS. Lectures on Natural Philosophy. London. 1807.

69. 1807. RUMFORD, B. GRAF von. Versuche und Beobachtungen ueber die Adhaesion der Wasserteilchen untereinander. *Gilb. Ann.*, Vol. 25, p. 121.

Experiments by Rumford plainly demonstrate the existence of a surface film in water under ordinary conditions. Small particles of heavy substances, like a needle, or fine silver wire, or even drops of mercury will float on water when they first pass through a layer of ether; but will sink without delay upon passing through alcohol. The mercury, when floating plainly rests imbedded in a cavity, separated from the water by a thin film, which seems to be connected with the glass. Rumford finally points out that the existence of a surface tension of the water is of the utmost consequence in the economy of nature. But for the influence of that force the breeze would carry away the water particles mechanically, much more easily than sand which is so readily blown up as dust and every continuous ocean breeze would result in an inundation.

70. 1807. LINK, H. F. Ueber Festigkeit und Fluessigkeit. *Gilb. Ann.*, Vol. 25, p. 133-146.

A liquid is characterized by the great mobility of its smallest particles, because of an almost entire absence of interior friction. Particles within the liquid are in perfect equilibrium since they are attracted (or repelled) equally on all sides by their neighboring particles. But particles composing the surface of the liquid, are attracted downward only, because there are no particles above to compensate for that downward force.

Thus the surface forms a film that is pressing against the interior of the fluid. This condition of the surface resembles the solid state, and some experiences on surface resistance (see No. 69,) strongly favor such a view. Link now argues that the solid condition consists in an interior multiplication of such surfaces, resulting in the formation of fibers and lamels. He declares the liquid condition to be the normal form of matter.

71. 1807. BIOT. On the Theory of Laplace. Reported by Gilbert. *Gilb. Ann.*, Vol. 25, p. 233-254.

The distinguishing feature of Laplace's theory is that all explanations of capillary phenomena are derived from the shape of the liquid surface. In plain surfaces there exists a force of unknown absolute value, pressing in a normal direction against the liquid. When this surface changes to concave, this force becomes less, in proportion to the curvature. When the surface becomes convex, this force increases in the same proportion.

If now a capillary tube be dipped into water or mercury, a concave or a convex meniscus is created respectively; but this meniscus cannot remain on a level with the outside horizontal surface, because in both cases the meniscus pressure is different from the outside surface pressure, exerted in opposite direction; and rise must therefore take place in the case of a concave meniscus, and depression in the case of a convex meniscus in order to equalize the difference in the contending normal forces.

It follows that rise or depression must increase when the curvature of the meniscus increases, that is, when the diameters of the tubes decrease.

Laplace arrives at these results by strictly mathematical reasonings and tests the correctness of his theory by applying it to different capillary phenomena.



- 72.** 1807. LINK, H. F. Fortgesetzte Untersuchung ueber Adhaesion tropfbarer Koerper. *Gilb. Ann.*, Vol. 26, p. 147-151.

Making experiments on the displacement of liquids from solid plates by other liquids, in order to decide between the theory of surface attraction by Carradori and the existence of repellent vapors as presumed by Prevost. (See Nos. 53 and 40.)

- 73.** 1807. TRALLES. Correction by Senkwagen (areometers.) *Gilb. Ann.*, Vol. 27, p. 255.

In determining specific gravities by means of areometers, the liquid when wetting the stem, rises around it, producing a force which exerts a pull downward, thus requiring a correction which may be determined by experiment.

- 74.** 1808. CLAIRAUT. *Théorie de la figure de la terre.* Paris, 1808, p. 105-128.

Clairaut was the first to subject the phenomenon of capillary action to an exact mathematical analysis, (see No. 64.) but his solution of the problem fails to account for the experimental law observed by Jurin. (See No. 16.)

- 75.** 1808. LINK. Ueber Anziehung und Verwandtschaft. *Gilb. Ann.*, Vol. 30, p. 12-22.

Reiterates his theory of the nature of the solid state, (the smallest particles of a solid are supposed to be liquid surfaces, in the shape of lamels or fibers,) (see No. 70.) Solution takes place by the liquid entering the interstices between the lamels, then by virtue of mutual attraction, the surfaces vanish, and the solid becomes fluid. Speed of solution is not always a measure of affinity, as it also depends on the physical conditions of the solvent and the body to be dissolved.

Chemical affinity is manifested sometimes by merely rubbing substances together, e. g., potassium sulfate and lead acetate liquefy under this condition; reversely, by an intimate mixture of potassium sulfate and calcium chlorid, double decomposition results, neither product being deliquescent.

- 76.** 1809. BIOT. On the Theory of Laplace, II. *Gilb. Ann.*, Vol. 33, p. 117-140.

Reports on Laplace's Supplement to the theory of capillary action (see No. 64,) which is practically a generalization of his former theory. (See No. 71.)

After establishing the law that in prismatic tubes of like nature, of whatever shape, the bulk of liquid raised above the level by capillarity, is in proportion to the inner circumference of their cross sections, Laplace proceeds to verify his theory by applying it to different capillary phenomena. Observations made by Gay Lussac and Hany are here recorded.

Finally reviewing preceding theories, Laplace acknowledges the close approach of Jurin's view (see No. 16,) to his own theory as laid down in this supplement.

- 77.** 1809. BRANDES and GILBERT. Ueber die Theorie von Laplace. *Gilb. Ann.*, Vol. 33, p. 1-14, 141-182, 275-338, 373-394.

Giving a detailed exposition of the theory of Laplace and of its exemplification by various capillary phenomena. (See Nos. 64, 71 and 76.)

- 78.** 1810. BUSSE. Versuche, um zwischen Cohesion und Adhaesion zu unterscheiden. *Gilb. Ann.*, Vol. 34, p. 152.

It is presumed that two well polished plates of marble or brass touching each other by their polished surfaces, are held together by two forces which perhaps obey the same law: 1) Cohesion, acting at infinitely small distances, and 2) Adhesion acting at finite spaces. When the plates are moved in a direction parallel to their surface, it is claimed that only the former force is opposing, but when pulled in a normal direction, both forces are to be overcome.

- 79.** 1814. LINK, H. F. Theorie der Fluessigkeit und Festigkeit. *Gilb. Ann.*, Vol. 47, p. 1-43.

The ultimate essence of fluidity consists in the perfect mutual neutralization of the attraction which the particles in the interior of the fluid exert upon themselves. In viscid liquids there is no complete neutralization, and this causes the particles to move less freely. Such a condition approaches the solid state, which becomes especially manifest at the surface of the liquids. (See No. 70.) Link credits Leidenfrost (See No. 28.) with having previously called attention to the solidity of liquid surfaces. Link then gives his views on solidity and electric action, and on various chemical phenomena.

- 80.** 1816. GIRARD. Mouvement des fluides dans les tubes capillaires. *Ann. Chim. Phys.*, (2) Vol. 1, p. 436.
- States that Dubuat (see No. 33a.) experimented on the flow of liquids through capillary tubes, and also reviews the work of Gerstner. (See No. 51.) From his own researches he arrives at a quadratic equation expressing the relation between the velocity of outflow, the constant height of the liquid and the length and diameter of the capillary tube. The quantity of outflow under definite conditions varied in the proportion of 1:4 when the temperature varied from 1° to 86° C. These variations he ascribes to the existence of a liquid film, which lines the inside of the tube, and which increases in thickness when the temperature is increasing. Girard calculates the thickness of this film to be not less than 6-10 mm. at 0° C., but at 100° not more than 1-1000 mm.
- 81.** 1816. HACHETTE. Mémoire relatif à l'écoulement des fluides par des orifices à minces parois et par des ajutages cylindriques ou coniques. *Ann. Chim. Phys.*, (2) Vol. 3, p. 78.
- Records the changes that take place in the velocity and in the shape of a liquid jet, passing through capillary tubes when the following influences are varying: Diameter, length and shape of the outlet tube, the surface against which it rests, the height and the nature of the liquid in the vessel, and the influence of the surrounding air.
- 82.** 1817. FARADAY. On the escape of gases through capillary tubes. *Quart. Jour. Science*, Vol. III, p. 354.
- Desiring to ascertain whether there was any connection between the mobility of gases and their specific gravities, Faraday observed the time which was necessary for different gases to escape through a capillary tube of 20 inches in length, attached to a copper vessel holding 100 cubic inches, during which time the pressure was reduced from 4 atmospheres to  $1\frac{1}{4}$ . The result seemed to demonstrate that the relative mobilities of the gases are in inverse ratio to their specific gravities. At low pressures, however, there was no apparent connection between the densities of gases and their passage through narrow tubes.
- 83.** 1817. PETIT. Observations sur les tubes capillaires. *Ann. Chim. Phys.*, (2) Vol. 4, p. 54.
- Defends the theory of Laplace against some doubts which were raised by Brunacci in *Giornale di Fisica, Chimica*, etc.
- 84.** 1817. GIRARD. Ecoulement linéaire de diverses substances liquides par des tubes capillaires de verre. *Ann. Chim. Phys.*, (2) Vol. 4, p. 146.
- The velocity of motion of a fluid through a capillary tube depends on two distinct influences:  
 The specific viscosity of the fluids.  
 The attraction of the material of the outlet tube for the fluid.  
 The latter influence causes the formation of a liquid film lining the interior of the outlet tube. (See No. 80.) At temperatures below the boiling point, this influence will prevail over the first one. It is shown, for example, that oil of turpentine, and even a syrupy solution of sugar in water require less time to fill a given volume than does alcohol flowing through the same tube at the same temperatures. However, near the boiling point of the fluids, the second influence will vanish, and the viscosity is then probably measurable by the length of time which is necessary to fill a given volume. The fact that mercury flows out equally fast at different temperatures, supports the film theory.
- 85.** 1817. HACHETTE. Sur les veines fluides qui se forment dans les ajutages cylindriques et coniques. *Ann. Chim. Phys.*, (2) Vol. 5, p. 52.
- Studied the conditions under which a fluid running through a tube, will fill out this tube, or contract within it thus partly separating from the tube.
- 86.** 1817. PETIT. Lettre relative à la critique de la théorie capillaire. *Ann. Chim. Phys.*, (2) Vol. 5, p. 404.
- Concerning the controversy with Brunacci, (see No. 83.)

- 86a.** 1817. EMMETT. On capillary action. *Phil. Mag.*, (2) Vol. 1, p. 115-332. (1817.)

Studied the influence of temperature on capillary phenomena. (See C. Wolf, *Pogg. Ann.*, Vol. 101, p. 550. (1857.)

- 87.** 1817. GIRARD. Sur l'écoulement de l'Ether et de quelques autres fluides par des tubes capillaires de verre. *Ann. Chim. Phys.*, (2) Vol. 6, p. 225-34.

Starting from the proposition that the viscosities of liquids, when they are near their boiling point, are then measurable by the time required for a given amount to flow through capillary tubes, (see No. 84.) Girard finds that the viscosities of ether, water and alcohol at their boiling points, are in the proportion of 80: 107: 300. Thus alcohol proves to be more viscid than water.

Girard further demonstrates that the viscosity of ether and water maintain their proportionality also at lower temperatures, while the viscosity of alcohol increases in a much greater ratio when the temperature decreases.

Finally Girard observed the ascent of ether, alcohol, milk and water in capillary tubes, finding, as he expected, their succession different from their classification according to their specific viscosities.

- 88.** 1819. LAPLACE. Considérations sur la théorie des phénomènes capillaires. *Ann. Chim. Phys.*, (2) Vol. 12, p. 5.

General reflections suggested by his theory on capillarity, (see No. 64.) also demonstrates that Thos. Young's idea of the existence of both an attractive and a repellent (caloric) power between the smallest particles (see No. 63.) is in accord with his own theory.

- 89.** 1819. GIRARD. Mémoire sur les atmosphères liquides, et leur influence sur l'action mutuelle des molécules solides qu'elles enveloppent. *Mém. Ac. R. Sc. Inst. France*, Vol. IV, p. 1-98.

Deduces certain laws from the phenomenon of particles settling within a liquid, advocating the existence of a liquid film surrounding each particle.

- 90.** 1821. YOUNG, THOMAS, Dr. (?) (A letter signed S. B. L.) Remarks on the depression of mercury in glass tubes. *Quart. Jour. Science*, Vol. XI, (1821) p. 83-85.

While rejecting a sweeping statement made by Mr. Ivory in the *Encyclopædia Britannica*, which abruptly denied to Thos. Young, all his merits with regard to the theory of capillarity, the latter or his representative points out that in the *Encycl. Brit. Suppl.*, (1819) Art. *Fluids*, edited by Mr. Ivory, there occurred a series of numerical errors in the figures for the depression of mercury in glass tubes.

- 91.** 1821. LAPLACE. Sur l'attraction des corps sphériques, et sur la répulsion des fluides élastiques. *Ann. Chim. Phys.*, (2) Vol. 18, p. 181.

Discusses the attraction one sphere exerts upon another which it surrounds, and gives a theory of the gaseous state, assuming each molecule to be surrounded by a heat atmosphere which counteracts the attraction between each two molecules. From the algebraic formula, which expresses his theory, the laws of Mariotte (Boyle) and of Gay Lussac are readily deducible.

- 92.** 1821. LAPLACE. Eclaircissements de la théorie des fluides élastiques. *Ann. Chim. Phys.*, (2) Vol. 18, p. 273.

A paper, largely embracing theoretical considerations.

- 93.** 1821. NAVIER. Sur les lois du mouvement des fluides, en ayant égard à l'adhésion des molécules. *Ann. Chim. Phys.*, (2) Vol. 19, p. 245.

Navier establishes an elaborate mathematical expression for the velocity of motion of liquids through square tubes, and verifies his result by applying to it the observations made by Girard. (See No. 80.)



94. 1822. LAPLACE. Addition au Mém. sur la théorie des fluides élastiques. *Ann. Chim. Phys.*, (2) Vol. 21, p. 22.

The solid, the liquid and the gaseous conditions are the result of the comparative magnitudes of the following forces:

- 1) Attraction between each molecule and those surrounding it.
- 2) Attraction between that molecule and the caloric atmosphere of the surrounding molecules.
- 3) The repulsion between its own caloric atmosphere and those of its neighboring molecules.

95. 1822. CAGNIARD, DE LA TOUR. Exposé de quelques résultats obtenus par l'action de la chaleur et de la compression sur certains liquides, tels que l'eau, l'alcool, l'éther sulfurique et l'essence de pétrole rectifiée. *Ann. Chim. Phys.*, (2) Vol. 21, p. 127.

When alcohol or petroleum ether or sulfuric ether are inclosed in a strong glass tube, and fill not more than half its volume, the liquid expands upon being heated, until it occupies about double its former space; when now the heat increases, the liquid disappears and the tube contains the vapor. Upon cooling, clouds appear inside the glass, and the liquid is formed again. In similar experiments with water, difficulty arises in that water corrodes the glass, impairing its transparency.

96. 1822. CAGNIARD, DE LA TOUR. Supplement to the former memoir. *Ann. Chim. Phys.*, (2) Vol. 21, p. 178.

Cagniard found that ether completely volatilizes in closed glass tubes at 160° C, exerting a pressure of 37-38 atmospheres, and alcohol at 207° C, exerting a pressure of 119 atmospheres. Water seems to completely volatilize at the temperature of melting zinc, (433° C.) A vacant space in the containing glass had to be allowed in each case for the expansion of the liquid prior to its volatilization.

97. 1822. FISCHER, N. W. Ueber die Eigenschaft der tierischen Blase, Flüssigkeiten durch sich hindurch zu lassen. *Gilb. Ann.*, Vol. 72, p. 300.

The property of animal membranes to be permeable for liquids was discovered by Fischer in 1812. Here he makes some general statements as to the conditions under which liquids pass through such membranes. He mentions, for example, that the duration of passage depends to a great extent on the nature of the membrane; thus, the sheep's bladder, although very thin, is not very permeable by liquids; only to about the same extent as that of oxen.

Fischer then describes the following striking phenomenon: A tube closed at the bottom by a bladder, and containing water and an iron wire, was placed in a solution of a cuprous salt, the level of the latter solution being higher than that of the water. The latter then rose to four inches above the outside level, while copper was deposited inside by the iron wire. In modifications of this experiment it was shown that rise took place only in case a chemical reaction was involved.

98. 1823. DOEBEREINER. Remarks on capillary action of fissures. (Communicated by Liebig.) *Ann. Chim. Phys.*, (2) Vol. 24, p. 332.

Relates his well-known experience where hydrogen which was kept over water in a bell jar, escaped through a crack in the glass, causing the water to rise inside to more than one-third of the interior volume. Oxygen, nitrogen and air did not show this behavior, which is due, according to Doebereiner, to the smallness of the atoms of hydrogen, which are at the same time surrounded by atmospheres of heat of much greater energy than those surrounding the atoms of other gases.

Doebereiner furthermore alludes to the experiments of Faraday (see No. 82,) and of Dr. Soemmering, who demonstrated that dilute alcohol may be concentrated by allowing it to stand in a glass with a bladder tied over its mouth; the vapors of water seem to pass through the pores of the bladder more readily than the vapors of alcohol.

99. 1823. BECQUEREL. Des courants électriques qui ont lieu dans les actions capillaires. *Ann. Chim. Phys.*, (2) Vol. 24, p. 337.

Becquerel observed that electric action takes place even in cases where chemical affinity is out of question, and concludes that capillary action produces electric currents. Platinum sponge or charcoal absorbing diluted acid, even the mere dipping of platinum foil into dilute acid, causes the needle of a fine galvanoscope to be deflected. The same phenomenon takes place when solid or liquid acids, or alkalis, or neutral salts are dissolved in water. Intensity and direction of the current is dependent on the conditions.

100. 1825. GILLEROU. On a singular capillary phenomenon. *Quart. Jour. Science*, Vol. XIX, p. 135.

A capillary column of mercury, which usually stands below the outside mercurial surface, may be raised above this level by most carefully raising the tube which contains it. The curvature of the surface of the column change on its way from convex to concave. But upon lowering the tube now a little, the surface of the column becomes convex, although it still stands above the level. Gillerou therefore concludes that the curvature of a fluid is but an accessory circumstance and does not determine the nature and height of capillary rise or depression.

101. 1825. GIRARD, T. S. On the attraction manifested at sensible distances by solid surfaces moistened by, or immersed in, a liquid. *Quart. Jour. Science*, Vol. XX, p. 379. Also see *Ann. Chim. Phys.*, (2) Vol. 29, p. 260.

Girard suspended two glass plates of equal size in water opposite to each other and imparted to each the motion of a pendulum. He then recorded the average time of one-half oscillation when the plates were reasonably apart. Now they were brought within such small distances (defined by intervening thin wires of known thickness) as to bring into mutual penetration the liquid layers assumed to exist upon the surface of each plate.

Measurements then demonstrated that the oscillating motion of the plates was manifestly retarded, which became the more evident the thinner a wire was employed. Therefrom Girard concludes that plates which are suspended near each other in a parallel position in liquids which are capable of wetting them, are perceptibly attracted by virtue of a power acting at finite and measurable distances, and emanating from the strata of liquid condensed upon the surfaces of the plates.

102. 1826. DUTROCHET. On Endosmosis. *Journal de Pharmacie*, (1826) First account of that phenomenon.

103. 1826. LINK, H. F. Ueber die Festigkeit der Koerper. *Pogg. Ann.*, Vol. 8, p. 25-37, 151-164, 283-298.

104. 1826. FARADAY. Ueber die Aufbewahrung von trocknen Gasarten ueber Quecksilber. *Pogg. Ann.*, Vol. 8, p. 124.

Three specimens of carefully dried oxy-hydrogen gas were kept for 15 months over mercury in glass bottles which were closed with well ground stoppers, and invertedly placed into a vessel containing sufficient mercury to reach to the neck of the bottles.

Examination of their contents after 15 months revealed the fact that one contained air, and the other mixtures of air and oxy-hydrogen gas. Faraday concludes that the air must have entered between the mercury and the glass, and thus proved that gases which are kept over mercury in glass tubes are liable to escape thorough the small space between the mercury and the walls of the glass.

Poggendorff adds in a note that this phenomenon may be referred to the same cause as that observed by Doebereiner. (See No. 98.)

105. 1827. MAGNUS, G. Ueber einige Erscheinungen der Capillari-taet. *Pogg. Ann.*, Vol. 10, p. 153.

Magnus is the author of an interesting experiment, which in a modified form, is mentioned by Tait (see later) viz., that the evaporation of water from the surface of an animal membrane, tightly fitting over the top of a glass tube, can draw upward a considerable column of mercury (three inches in these experiments.)

To such an evaporation he likens the escape of hydrogen through fissures in Doebereiner's experiments. (See No. 98.)

Pronouncing the action of animal membranes to be a capillary phenomenon, and alluding to the discovery of the membrane phenomena (endosmosis) by Dutrochet, (see No. 102.) he observes that water passes through the pores of a bladder more easily than salt solution, which explains why the rise invariably occurs in those tubes containing the brine. On this basis he gives a complete explanation of the phenomenon described by Fischer, (see No. 97.)

- 106.** 1827. FISCHER, N. W. Ueber das Verhalten der Risse in Gläsern zu den darin enthaltenen Flüssigkeiten. *Pogg. Ann.*, Vol. 10, p. 481.

Makes distinction between the effects of wide and narrow fissures. He observed that the very narrowest fissures did not allow any interchange of liquids, except in one case on record, where silver nitrate was kept in the fissured glass which was standing in water; the latter afterwards showed no trace of silver by means of delicate tests; but the electric current deposited traces of silver in the inside vessel and formed zinc or copper nitrate in the outside glass.

- 107.** 1827. FISCHER, N. W. Capillärwirkungen der tierischen Blase. *Pogg. Ann.*, Vol. 11, p. 126.

Confirming in general the results obtained by Magnus, (see No. 105.) he records among other observations the fact that the action of water through a membrane is especially remarkable towards cupric chlorid, but insensible towards silver nitrate, gold solution and stannous chlorid, because these solutions are reduced or decomposed during the operation.

With reference to Magnus' experiment on the rise of mercury caused by evaporation of water, (see No. 105.) Fischer states that evaporation of water may draw up the mercury much higher than three inches, probably to the height of the mercury in the barometer, provided that the space immediately below the bladder is filled with water.

Fischer further remarks that alcohol does not readily penetrate a bladder, which sufficiently explains the observation of Soemmering. (See No. 98.)

- 108.** 1827. POISSON. Note sur les effets qui peuvent être produits par la capillarité et l'affinité des substances hétérogènes. *Ann. Chim. Phys.*, (2) Vol. 35, p. 98-101. Also see *Pogg. Ann.*, Vol. 11, p. 134.

He accounts for the phenomenon of endosmosis by supposing the pores of the membrane to act as capillary tubes. Of two liquids on opposite sides of a membrane, the one which would rise higher in a capillary tube of the same material as the membrane would also pass into the other liquid. His explanation, however, fails to recognize the existence of the current in opposite direction.

- 109.** 1827. DUTROCHET, HENRI. Nouvelles observations sur l'endosmose. *Ann. Chim.*, (2) Vol. 35, p. 393-400. See also *Pogg. Ann.*, Vol. 11, p. 138.

Dutrochet holds that the flow of liquids in both directions through membranes speaks against Poisson's theory. (See No. 108.) He further finds that while in the case of water and other liquids, the change of level takes place in conformity with the superior capillary rise of water, in other cases (oil of lavender, alcohol of 36° Be., olive oil.) the flow occurs contrary to what should be expected from the observed capillary ascents. Poggendorff in a note points out the probable fallacy of the latter experiments. Dutrochet remarks that these phenomena may also be observed with porous thin plates of inorganic material, and finally emphasizes the bearing which endosmosis has upon physiological processes.

- 110.** 1828. IVORY. On the Theory of Capillary Action, and the Depression of Mercury in the tubes of Barometers. *Phil. Mag.*, Vol. 3, (or 5?) p. 1-11.

- 111.** 1828. MUNCKE, G. W. Ueber Leidenfrost's Versuch. *Pogg. Ann.*, Vol. 13, p. 235.

Here the following literature on the subject is recorded: Leidenfrost (see No. 28.) Klaproth, *Allg. Jour. Chem.*, Vol. 7, p. 646. Rumford, *Gilb. Ann.*, Vol. 17, p. 33. Doebereiner, *Schweigger's Journ.*, Vol. 29, p. 43, or *Gilb. Ann.*, Vol. 72, p. 211, and Vol. 87, p. 447.

- 112.** 1828. DUTROCHET. Nouvelles recherches sur l'endosmose et l'exosmose. *Ann. Chim. Phys.*, (2) Vol. 37, p. 191.

Makes use of his Endosmometer to render the osmotic action visible. When water is placed in the outside part of this instrument, and an aqueous liquid miscible with water, (e. g. a solution) inside, water invariably passes the membrane in greater quantity than the inner liquid does in opposite direction. Hence the latter rises in the stem.



- 113.** 1830. PRECHT. On the Adhesion of Metals. *Quart. Jour. Science*, (2) Vol. 7, p. 196.

Precht observed that, if two plates of copper adhere with a force of 21 grains, then one of these copper plates will adhere to a similar plate of bismuth, zinc, tin, or lead, with the same force, although two plates of any of these latter metals will adhere with less force.

- 114.** 1830. POISSON. Mémoire sur l'équilibre des fluides. *Mém. de l'Acad. des Sciences*, Vol. 9, p. 1-88. (1830) See also *Quart. Jour. Science*, (3) Vol. 1, p. 595.

Arriving at several equations pertaining to the equilibrium of fluids, he contends that capillary phenomena are due to molecular action, resulting from both an attraction and repulsion by caloric atmospheres, and modified not only by the form of the surface, as maintained by the theory of Laplace, (see No. 64,) but also by a peculiar state of compression of the liquid within its surface film.

- 115.** 1830. GAUSS. Principia generalia theoriae fluidorum in statu aequilibril. *Comment. Soc. Gotting.* Vol. 7, p. 39-83. See also *Gauss' Werke*, Vol. 5, p. 29-77, (1877).

Gauss arrived at the equation of Laplace for the capillary surface of a liquid, but approached the subject from a broader principle, that of the conservation of energy. Further details cannot be given here, as they involve the extensive use of purely mathematical terms.

- 116.** 1830. FISCHER, N. W. Leidenfrost's Versuch. *Pogg. Ann.*, Vol. 19, p. 514.

Fischer thinks that Leidenfrost's Phenomenon, in the case of water, consists in a decomposition into Oxygen and Hydrogen, induced by heat, and in their spontaneous recombination, aqueous vapors being formed.

- 117.** 1831. POISSON. Nouvelle théorie de l'action capillaire. *Ann. Chim. Phys.*, (2) Vol. 46, p. 61-70.

Gives a brief review of the mathematical development up to his time of the theory of capillarity embracing the theories of Clairaut, Thomas Young, Laplace and Gauss. He claims the theories of Laplace and Gauss to be deficient in that they do not take into account the variation in density of a liquid near its free surface and near their surface of contact with a solid body. (See No. 114.) On these premises he announces his "Nouvelle théorie" to be established.

- 118.** 1831. POISSON. *Nouvelle théorie de l'action capillaire*. Paris, 1831.

The purpose of this work is to rectify an alleged omission in all preceding theories of capillarity, by evolving an equation for the capillary surface of a liquid, at the same time taking into account the variation in density near its surface and near its contact with a solid body. (See No. 117.) Poisson claims that if this point is ignored, the theory would neither lead to capillary elevation nor depression. Subsequent chapters give a mathematical treatment of various capillary phenomena, evolved on the same basis.

In Notes and Additions he gives his views of the molecular constitution of matter, especially liquids, (see No. 114,) also some experimental material, such as the capillary behavior of mixtures, and the depression of Mercury in capillary tubes, recording Dulong's theory. (See No. 124.)

- 119.** 1831. DUTROCHET, HENRI. Expériences sur la circulation des liquides dans les tubes de verre verticaux. *Ann. Chim. Phys.*, (2) Vol. 48, p. 268-281.

Water contained in a vertical glass tube exhibits a circulating motion when different temperatures are applied to opposite sides of the glass. At or above 15° R. the motion responds readily to slight thermal differences; at or below 10° R. there was no motion observed even when the change in temperature was 5°. Addition of Acids, Alkalies and Salts increased the sensibility, also diffused light seemed to have a decided influence on the motion of pure water.

- 120.** 1832. DUTROCHET, HENRI. Recherches sur l'endosmose et sur la cause physique de ce phénomène. *Ann. Chim. Phys.*, (2) Vol. 49, p. 411. Also see *Pogg. Ann.*, Vol. 28, p. 459.

Studying the osmotic action of water towards solutions of Sodium chlorid and Sodium sulfate of equal densities, he found the ratio of their osmotic velocities equal to exactly 1:2. An exactly parallel relation he thinks to exist between the capillary rise of both liquids and of water in the same glass tube.

In *Pogg. Ann.* a critical report on this paper is given.

- 121.** 1832. DUTROCHET, HENRI. Du pouvoir d'endosmose considéré comparative dans quelques liquides organiques. *Ann. Chim. Phys.*, (2) Vol. 51, p. 159. Also see *Pogg. Ann.*, Vol. 28, p. 359.

Preparing solutions of Gelatine, of Gum arabic, of Sugar, and of Albumen, all of equal density, and determining the velocity of endosmosis of water towards them severally, he finds the osmotic power increasing in the following order:

Gelatine; Gum; Sugar; Albumen; the relation between Gelatine and Albumen being as 1:4.

- 122.** 1832. BUFF, H. Leidenfrost's Versuch. *Pogg. Ann.*, Vol. 25, p. 591.

Buff sees in the phenomenon the natural effect of heat, which counteracts adhesion between fluid and solid by increasing the distance between their molecules. Absence of adhesion hinders the passage of heat from the glowing surface to the fluid, hence evaporation is retarded. If chemical affinity exists between both, the contrary takes place.

Buff finally verifies and discusses Perkin's experiment (described in No. 111.) in which it was demonstrated that water and steam contained in a vessel with red hot walls will not escape through a small opening at the bottom of the vessel.

- 123.** 1832. BESSEL. Beobachtungen in Bezug auf die Capillarität beim Barometer. *Pogg. Ann.*, Vol. 26, p. 451-455.

Bessel observed that the meniscus of Mercury in the longer arm of a barometer gradually diminished and even became concave. During this change air had collected above the mercury. After expelling this air, the meniscus became strongly convex, and the mercurial height was considerably lessened, seemingly more than if capillarity alone had been the cause.

- 124.** 1832. DULONG. Beobachtungen in Bezug auf die Capillarität beim Barometer. *Pogg. Ann.*, Vol. 26, p. 455-458. from Poisson, *Nouv. Théorie*, (see No. 118).

The phenomenon of Mercury adhering to glass in freshly made barometers, observed by Dom. Casbois, he explains by the theory that during the boiling, Mercuric Oxid is formed which greatly modifies the action between Mercury and glass.

When Mercury is boiled in an atmosphere of Hydrogen, no such phenomenon is noticeable.

- 125.** 1832. BOHNENBERGER. Beobachtungen in Bezug auf die Capillarität beim Barometer. *Pogg. Ann.*, Vol. 26, p. 458-463.

Determined experimentally the capillary depression of Mercury in barometric tubes of different diameters, in comparison with a normal barometer. An addition of 1.60 per cent. of Silver to Mercury renders the mercurial surface less convex and diminishes the capillary depression. Air seems to have a depressing influence on Mercury in barometric tubes.

- 126.** 1832. MAGNUS, G. Ueber die Verdunstung von Flüssigkeiten aus Haarröhrchen. *Pogg. Ann.*, Vol. 26, p. 463.

By placing several tubes of different widths, open on top, and each filled with water to a certain mark, under the receiver of an air-pump, containing a dish with sulfuric acid, it was found that evaporation did not take place in proportion to the free surfaces of the water, but that the column of water decreased more rapidly in capillary than in wider tubes.

- 127.** 1832-33. LINK, H. F. Darstellung von Poisson's Theorie der Capillarität. *Pogg. Ann.*, Vol. 25, p. 270-287, (1832). Vol. 27, p. 193-238, (1833).

The first part contains a critical comparison between Poisson's and Laplace's theories. The second a detailed exposition of Poisson's Nouvelle théorie. (see No. 118). Pronounces Poisson's theory of the variation in density to be an arbitrary assumption which he asserts we will never be able to verify.

- 128.** 1833. LINK, H. F. Neue Versuche über die Capillarität. *Pogg. Ann.*, Vol. 29, p. 404-414.

By using plates of glass, copper, zinc, etc., placed at an angle to each other, he observed the height to which different liquids (Water, Sulfuric and Nitric Acids, Alcohol, Ether,) rose at the line of approach. The height seemed to be the same in all cases. (See No. 129.)

- 129.** 1834. LINK, H. F. Neue Versuche über die Capillarität. *Pogg. Ann.*, Vol. 31, p. 593-599.

Records the fact that water rises to the same height between parallel plates of copper, zinc or glass. The following liquids are named in declining order with regard to the height to which he observed them to rise between parallel and equidistant plates, viz: Strong Acids, Water, Caustic Alkali, Potassium Acetate, Alcohol, Ether.

- 130.** 1834. GRAHAM, TH. On the Law of the Diffusion of Gases. *Phil. Mag.*, (3) Vol. 2, p. 175-190, 269-276, 351-358. See also *Pogg. Ann.*, Vol. 28, p. 331-358.

Starting from Doebereiner's observation, (see No. 98.) he evolves the following law of diffusion: When two gases without chemical effect upon each other, are separated by means of a porous membrane, the volume of the one gas passing through this membrane stands to the volume of the other gas passing in the opposite direction, in inverse ratio as the square roots of the densities of both gases, provided the pressure on both sides of the membrane remains the same.

- 131.** 1834. DRAPER, J. M. Some experimental researches to determine the nature of capillary attraction. *Franklin Inst. Jour.*, Vol. 14, p. 147-165.

From many conclusive experiments (e. g. the generation of electricity by the simple act of separating a glass dish from a surface of Mercury,) the author infers that capillarity is mainly an electrical phenomenon. (See No. 99.) With regard to Huyghen's phenomenon (see No. 7.) he demonstrates that electric discharges are taking place, whenever the mercury drops from its unusual height to its normal level. He also seeks to explain the phenomenon of osmosis and various physiological phenomena by the electrical theory.

- 132.** 1835. JERICHAU, E. B. Ueber das Zusammenströmen flüssiger Körper, welche durch poröse Lamellen getrennt sind. *Pogg. Ann.*, Vol. 34, p. 613.

Water and sugar solution contained in a U tube and separated by means of a drop of mercury, will pass into each other (the water with greater velocity) through the space between the mercury and the glass. (Compare No. 104.)

When using membranes, there is always a flow in both directions, but a general law, like that of Graham for gases, (see No. 130.) was not observable for solutions. Nor could a definite relation be observed between osmosis and capillarity as it was supposed to exist by Dutrochet. (See No. 120.)

- 133.** 1835. FRANKENHEIM, M. L. *Die Lehre von der Cohäsion*, Breslau, 1835.

- 134.** 1835. CHALLIS, REV. JAMES. Report on the Theory of Capillary Attraction. *Brit. Assoc. Report*, Vol. 4, p. 253-294.

The review comprises an historical introduction, and subsequently a detailed exposition of the works of Th. Young, Laplace, Poisson, Gauss and Link. (See Nos. 63, 64, 118, 115, 128.)



- 135.** 1836. FRANKENHEIM, M. L. Ueber die Cohäsion der flüssigen Körper. *Pogg. Ann.*, Vol. 37, p. 499

Gives a table which contains the constants of capillarity for a number of liquids, e. g., water, aqueous solutions of acids, alkalies and salts, also ethers and volatile oils.

- 136.** 1836. DRAPER, J. W. Experiments on Endosmosis. *Franklin Inst. Jour.*, Vol. 17, p. 177-182. Vol. 18, p. 27-31.

The phenomena of osmosis applied to gases, become the more pronounced, the smaller the pores of the intervening medium. This the author demonstrated by using films of gold leaf and of india rubber, and finally liquid films, these being the most suitable media, because by varying the thickness of the film, the speed of osmosis may be regulated at will. Interesting experiments are adduced to illustrate this point. The motion through a barrier ceases when there is identity of chemical composition on both sides.

- 137.** 1836. DEGEN, F. Versuche über die Netzbarkeit der Oberfläche verschiedener Körper. *Pogg. Ann.*, Vol. 38, p. 449.

Heat according to the author's experiments is a proper means to produce the wetting of solids by liquids. He concludes that the adhesion of the air to the solid is often responsible for its not being wetted by the liquid.

- 138.** 1837. BAUDRIMONT, A. Explication du phénomène que l'on observe en versant de l'eau sur des corps chauffés jusqu' au rouge. *Ann. Chim. Phys.*, (2) Vol. 61, p. 319.

Baudrimont determines among other points the temperature of the liquid in the red hot vessel, and observes that the temperature of boiling water decreases when poured into such a vessel. He finally pronounces the phenomenon to be simply a process of slow evaporation. (See No. 140.)

- 139.** 1836. CHALLIS, REV. JAMES. On Capillary Attraction and the molecular forces of fluids. *Phil. Mag.*, (3) Vol. 8, p. 89.

The author endeavors to show that the superficial variation of density in liquids (see No. 117.) may be neglected and Laplace's Theory of incompressibility upheld, if it is assumed that the fluid molecules possess both a feebly attractive and a strongly repellent force. The repellent power however extends over a small, the attractive power over a much larger, yet immeasurably small area. Such a molecular constitution allows an easy explanation of the fluid condition.

- 140.** 1836. CHALLIS, REV. JAMES. On the Phenomena of drops of oil floating on water. *Phil. Mag.*, (3) Vol. 8, p. 288.

Explains the phenomenon of oil spreading on water by applying thereto his theory on fluidity. (See No. 139.)

- 141.** 1836. LAURENT, AUGUSTE. Phénomènes que présente l'eau versée sur des corps chauffés au rouge, et sur quelques illusions d'optique. *Ann. Chim. Phys.*, (2) Vol. 62, p. 327.

Contrary to the observations of Baudrimont, (see No. 138,) who found the temperature of the drop of water in the red hot crucible to be not more than 50° C, Laurent observed 99°, by direct measurement (dipping a thermometer into the liquid,) not less than 95° C. Slow evaporation takes place when no wetting occurs, and rapid evaporation in the opposite case. The fluid touches only a few points, evaporation throws the liquid upward, causing it to vibrate and rotate, and to form symmetrical figures. (See No. 195.)

- 142.** 1837. AVOGADRO. Expériences sur quelques points douteux relatifs à l'action capillaire. *Ann. Chim. Phys.*, (2) Vol. 65, p. 409-443,

Experimental researches, undertaken with the aim to verify or correct the values for the constants of capillarity of Mercury, as found by Gay Lussac (see No. 64,) and Poisson. (See No. 118.)

Avogadro determined the height of rise of Mercury in amalgamated tubes, and the angle which Mercury forms with moistened and dry glass tubes, and with Iron and Platinum, showing that the latter metal forms a greater angle with Mercury than Glass and Iron.

- 143.** 1838. DUPREZ, F. Description of a phenomenon taking place upon mixing Alcohol and Water. *Bull. Acad. Roy. Belg.*, (1) Vol. 5, p. 402.

When one or two drops of alcohol are added to water in a test tube, air bubbles arise in the liquid, forming a surface scum. Soon afterwards a fine jet of bubbling liquid comes out of the surface, sometimes as high as 3 centimeters. The motion gradually lessens and disappears.

- 144.** 1838. DRAPER. Ein Diffusionsversuch. *Pogg. Ann.*, Vol. 43, p. 88. Also see *Philos. Mag.*, (3) Vol. 11, p. 559.

Place a film of viscid soap lather over the mouth of a 2 ounce vial; place over this vial a jar of Nitrous Oxid; in a few seconds the horizontality of the film will be disturbed, it will become convex, and at the end of 2 minutes it will form the greater part of a sphere 2 inches in diameter exhibiting brilliant colors.

- 145.** 1838. MILE, J. Versuch einer neuen physika schen Theorie der Capillarität. *Pogg. Ann.*, Vol. 45, p. 287-332 A) and 501-540 (B) See also *Lieb. Ann.*, Vol. 32, p. 191, (1839).

A)—In a liquid bounded by a plane surface the molecules are supposed to exist in an arrangement similar to that of a pile of cannonballs, each central ball environed by twelve others, their mutually attractive and repellent forces being in equilibrium. Any mechanical deformation of the surface changes the distances between the molecules, and calls into existence a tendency of the fluid to resume the plane surface.

On this principle, a free liquid mass, not inclosed in a vessel, (e. g. a drop) must assume the globular form, that is, bounded by an infinitely great number of planes. Similarly the formation of bubbles may be explained, and the surface of a drop or of a bubble must exert an inward pressure, the surface tension. By virtue of this tension depression and rise take place in capillary tubes, depression corresponding to the formation of a drop, and rise to that of a bubble. (See No. 71.)

B)—By assuming capillary repulsion preponderant over attraction, the author here accounts for certain thermal capillary phenomena, such as the fugitive motion of water in a horizontal tube, if heated at one end; also for the repulsion observable between Water and Alcohol, and a multitude of other phenomena.

- 146.** 1840. EMSMANN, A. H. Bildung des Leidenfrost'schen Tropfens auf Glas. *Pogg. Ann.*, Vol. 51, p. 444.

Emsmann demonstrates the phenomenon by using a narrow glass tube ending in a bulb containing water, which is briskly heated over a lamp. He also observes that the water is not decomposed in the process. (See No. 116).

- 147.** 1840. BUFF, H. Ursache des veränderlichen Einflusses der Capillarität beim Barometer. *Lieb. Ann.*, Vol. 36, p. 113.

His experiments tend to support Dulong's view, (see No. 124.) Upon repeatedly boiling mercury in barometric tubes and admitting the air, red Oxid of Mercury was seen to be formed, the meniscus became flat and adhered to the glass, even when near the boiling point. Boiling in an atmosphere of Carbonic Acid gas did not materially affect the curvature of the meniscus; but boiling the mercury with some Oxid of Mercury in a current of Carbonic Acid gas caused the meniscus to become concave after cooling.

- 148.** 1840. KOPP, H. Ueber die Cohäsion einiger Flüssigkeiten. *Lieb. Ann.*, Vol. 35, p. 230-234.

Determined the cohesion of Water, Alcohol and Rape Oil by the force necessary to tear asunder a known surface of either of these liquids. Instead of using the customary adhesion plates, he suspended from one arm of a balance a small bell jar of known dimensions, filled with the liquid dipping into a reservoir containing the same liquid.

- 149.** 1840. RUSSELL, J. S. On Floating Bodies. *Proc. Roy. Soc. Edinbg.* Vol. 14, p. 47-109.

The aim of the investigations, which were conducted on the largest possible scale, was to determine the laws between the velocity of motion of floating bodies and the resistance of the fluid, and to apply the results to the purposes of navigation.

- 150.** 1841. HENRY. Durchdringung des Bleis von Quecksilber. *Pogg. Ann.* Vol. 52, p. 187.

Henry succeeded in transferring Mercury from an upper watchglass to another below, by means of a solid rod of lead,  $\frac{1}{4}$  inch thick, bent in the shape of a siphon. In 5 to 6 days all the mercury had passed, and thus must have traversed the capillary interstices of the rod of lead.

- 151.** 1841. OERSTED, J. C. Eine neue Vorrichtung zum Messen der Capillarität. *Pogg. Ann.* Vol. 53, p. 614.

The apparatus consists essentially of a non-capillary U tube, one arm of which is capped by a plate containing the capillary bore. The latter is then capable of suspending a liquid column whose height is equal to the distance from the lower surface of the plate to the level of the liquid in the other arm of the U tube.

- 152.** 1841. SIMON, (de Metz). Recherches sur la capillarité. *Comptes Rendus*, Vol. 12, p. 892-94. (See No. 202.)

- 153.** 1841. FRANKENHEIM and SONDHAUSS. Ueber die Capillarität der flüssigen Körper bei verschiedenen Temperaturen. *Erdmann's Journal*, 1841, p. 401-245.

The authors record the specific gravities and corresponding constants of capillarity of the following liquids at varying temperatures: Water, Alcohol of different strengths, Ether, Carbon disulfid, Sulfuric Acid and Caustic Potash. The capillarities decrease at a greater ratio with the temperature than do the specific gravities, which contradicts part of Laplace's theory. (See No. 64).

- 154.** 1842. PLATEAU, J. Ueber die Erscheinungen bei einer freien und der Wirkung der Schwerkraft entzogenen Flüssigkeit. *Pogg. Ann.*, Vol. 55, p; 517-519. From *Bull. Acad. Brux.*, Vol. 9, p. 17.

The author's well-known experiment is here recorded wherein he demonstrates that a mass of oil suspended in a mixture of alcohol and water of equal density, assumes the globular form, and becomes flattened into an ellipsoidal body by rotation.

- 155.** 1842. PLATEAU, J. Ueber die Erscheinungen bei einer freien und der Wirkung der Schwerkraft entzogenen Flüssigkeit. *Pogg. Ann.*, Vol. 56, p. 167-169.

Continuing his fundamental experiment (see No. 154,) the author observes the rise of the oil in wide tubes dipped into the oil globule and indicates precautions necessary in order to succeed in this experiment.

- 156.** 1842. BIEWEND, E. Ein Adhäsionsphänomen. *Pogg. Ann.*, Vol. 57, p. 164.

Globules of freshly melted gold, chemically pure, also alloys with silver containing 50 per cent. gold, were seen to adhere strongly to one another, losing this power upon prolonged exposure to the air; pure silver did not show this phenomenon.

- 157.** 1842. BEEK, A. VAN. Eigenschaften des Oels, die Meereswogen zu besänftigen und das Wasser durchsichtig zu machen. *Pogg. Ann.*, Vol. 57, p. 419-452. Also see *Ann. Chim. Phys*, (3) Vol. 4, p. 257.

Gives numerous historical references, most of which proclaim the efficacy of oil in pacifying the waves. (See No. 31.) He suggests the use of oil for the purpose of protecting the dams and dikes in Holland against the erosive influence of stormy seas.



- 158.** 1842. BRAVAIS. Nouvelles tables des dépressions de mercure dans les tubes du baromètre. *Ann. Chim. Phys.*, (3) Vol. 5, p. 492-508.

A final table records the depression of Mercury for tubes of different diameters ranging from 4 to 20 mm, and for an angle of contact between Mercury and Glass, varying from  $15^{\circ}$  to  $48^{\circ}$ .

- 159.** 1842. DUTROCHET, HENRI. Observations relatives à l'action motrice exercée sur la surface de plusieurs liquides tant par l'influence de la vapeur de certaines substances que par le contact immédiat de ces mêmes substances. *Comptes Rendus*, Vol. 14, p. 1028-1042 (2) and Vol. 15, p. 15-28.

A drop of Ether suspended over concentrated Sulfuric Acid covered with flowers of Sulfur, will attract the powder. But when the acid is diluted below a specific gravity of 1.546 (equivalent to 2 Vols. of acid and 1 Vol. of water) the Ether will repel it. When the Ether touches the Acid, the phenomena are reversed, and seem to observe the same dividing line in specific gravity as before. Similar conditions exist for Tartaric and Nitric Acids, when employing Ammonia, or Oil of Turpentine, etc., as the volatile liquids.

- 160.** 1843. BRUECKE, E. Beiträge zur Lehre von der Diffusion tropfbar flüssiger Körper durch poröse Scheidewände. *Pogg. Ann.*, Vol. 58, p. 77-91.

The author points out that diffusion cannot consist merely of an exchange of fluids on both sides of the membrane, because concentrated solutions of Lead Acetate and Potassium Bichromate, when separated by a membrane, do not precipitate, even though diffusion be induced by dissolving sugar in either of these liquids.

The author also refutes the prevailing notion that strong chemical agents, as Sulfuric Acid, Nitrate of Silver or Nitric Acid destroy the action of animal membranes upon solutions.

- 161.** 1843. ——— Report of a Commission regarding the effect of Oil on the Waves of the Sea. *Pogg. Ann.*, Vol. 60, p; 316.

The report of the committee on the subject ventilated by Van Beek (see No. 157,) is not favorable.

- 162.** 1843. POISEUILLE. Recherches expérimentales sur le mouvement des liquides dans les tubes de très petits diamètres. *Ann. Chim. Phys.*, (3) Vol. 7, p. 50-74.

He established empirically the law that the quantity of effusion of liquids through capillary tubes is in inverse ratio to the length of the tube, and in direct ratio to the pressure, and to the fourth power of the diameter of the tube.

There is a minimum for the length of the tubes dependent solely upon their diameter, below which the law does not hold good. The experiments of Dubuat, (see No. 32a.) Gerstner, (see No. 51.) and Girard (see No. 87.) were carried on with tubes of insufficient length. There is no connection between capillary rise in tubes and the time of effusion, at least not for mixtures of Alcohol and Water.

- 163.** 1843. BRUECKE, ERNST. Ueber das Bluten des Rebstockes. *Pogg. Ann.*, Vol. 63, p. 177-214.

In his treatise he discusses a very meritorious work on the motion of sap in plants, "*Vegatable statics, or an account of some statical experiments on the sap in vegetables, etc.*," by Stephen Hales, London, 1727.

- 164.** 1844. CHORON. Leidenfrost's Versuch auf Flüssigkeiten. *Pogg. Ann.*, Vol. 63, p. 352. See also *Comptes Rendus*, Vol. 19, p. 581.

Observed that Sulfuric Ether, when dropped upon Water, Mercury, Coal Oil, Nitric Acid, which are previously warmed to  $54^{\circ}$  C. showed the same behavior as when water is dropped upon red hot metallic surfaces.

- 165.** 1844. BECQUEREL. *Traité de Physique*, Paris, 1844, Vol. 2, p. 243.

Studied the influence of temperature on the power necessary to separate adhesion plates from water. (See No. 173.) While the temperature varied from  $12^{\circ}$  to  $73^{\circ}$  C, the weight which was necessary to bring about separation, decreased by  $\frac{1}{4}$  of its value, while the density of the water decreased only by 0.02. This supports the results obtained by Frankenheim and Sondhauss. (See No. 153.)

- 166.** 1844. POGGENDORFF. On the Discovery of the phenomenon of Diffusion of Liquids. *Pogg. Ann.*, Vol. 63, p. 50.

NOLLET has first described that phenomenon in *Histoire de l'Acad. Roy. des Sciences*, Paris, 1748, (1752); the passage is quoted.

- 167.** 1844. DRAPER, JOHN W. *A treatise on the forces which produce the Organization of plants*. New York, 1844.

The author recognizes capillary forces as the powerful agents instrumental in the building up of plants. He sees in the action of sunlight the ultimate cause of both the upward and downward motion of the sap in plants. This agency in decomposing carbonic acid gas on the upper surface of the leaves, creates a mucilaginous fluid, which is constantly displaced and forced downward by the thinner rising fluid, the latter having a greater attraction for the cell walls than is possessed by the mucilaginous fluid. On the same mechanical principle the motion of the blood in the capillaries and the function of the heart are also explained. The treatise further contains several of his memoirs on capillary attraction, (e. g. No. 136.) electricity and the chemical action of light.

- 168.** 1845. BOUTIGNY. Recherches sur la formation de la vapeur. *Comptes Rendus*. Vol. 20. p. 614-616.

Determined the lower limits of temperature capable of producing the repulsion or spherical state for different liquids, as Water, Sulfuric Acid, Alcohol, Ether and various Oils. Discusses the important bearing which Leidenfrost's phenomenon has upon the safety of boilers.

- 169.** 1845. BOUTIGNY. Extract d'un Mémoire contenant des expériences destinées à prouver que les corps à l'état sphéroïdal réfléchissent presque complètement le calorique rayonnant. *Comptes Rendus*, Vol. 20, p. 885.

Demonstrates rather conclusively that the radiating heat emitted by the red hot vessel, does not enter the spheroidal liquid but is reflected from its surface. He also states that the temperature of the drop of water in the red hot vessel is  $95^{\circ}$  C. (See No. 141.)

- 170.** 1845. DRAPER, JOHN. Is Capillary Attraction an electric Phenomenon? *Phil. Mag.*, (3) Vol. 26, p. 185. See also *Pogg. Ann.*, Vol. 67, p. 284, (1846).

The author supports his view of the electrical nature of capillarity by some additional experiments, (see No. 131.) for example: A drop of water upon a surface of Mercury that is connected with the negative pole of an electric battery, will spread over the Mercury as soon as the water is touched by the positive pole. Glass plates adhering to each other, possess free electricity after separation.

- 171.** 1846. HAGEN, G. H. L. Ueber die Oberfläche von Flüssigkeiten. *Pogg. Ann.*, Vol. 67, p. 1-31, 152-172. From *Abh. Berl. Acad.*, (1845) p. 41-84. Also see *Ber. Berl. Acad.*, (1845) p. 166-169 and *Lieb. Ann.*, Vol. 60, p. 128-140.

The free surface of a liquid is in a state of tension, by virtue of which for example, the greatest velocity of a stream of water, does not occur in the surface, but at some distance below.

Hagen now evolves several formulas for the capillary surface of a liquid either touching one plate or rising between parallel plates or in capillary tubes, and tests the correctness of these formulæ by actual measurements. All these formulæ contain an expression for the surface tension of the liquid, which is defined as the weight necessary to tear asunder a liquid surface along the unit of length, and is determinable by experiment.

Hagen finally verified the value which he thus obtained for the surface tension by calculating it also from the weight of drops falling from a surface of known dimensions.

- 172.** 1846. DONNY, F. Mémoire sur la cohésion des liquides, et sur leur adhérence aux corps solides. *Ann. Chim. Phys.*, (3) Vol. 16, p. 167. See also *Pogg. Ann.*, Vol. 67, p. 562-584 and *Lieb. Ann.*, Vol. 60, p. 141.

Liquids holding gases in solution, have hardly any cohesion. An aqueous column filling half of a closed glass tube 1 m long, may be torn for moments into 2 parts, by giving it a slight shock perpendicularly. But as the gases are expelled, the cohesion increases, until at their complete expulsion the cohesion is very powerful. Then it will be found impossible to tear asunder a column of water or sulfuric acid of 1 m length, even if an almost complete vacuum is applied at its lower end. On these lines the author demonstrates also some interesting phenomena on the retardation of boiling, succeeding in raising the boiling point of water as high as 135° C. Hence if the process of boiling depends so much on the quantity of gas dissolved, it seems hardly proper to speak of a definite boiling point of a liquid.

- 173.** 1847. BRUNNER, C. Untersuchung über die Cohäsion der Flüssigkeiten. *Pogg. Ann.*, Vol. 70, p. 481-529. Also see *Lieb. Ann.*, Vol. 64, p. 140.

He determined the height of rise of Water, Sulfuric Ether and Olive Oil in capillary tubes of known diameter at different temperatures, proving against Laplace and Poisson, that the heights decrease in a greater ratio than the specific gravities decrease. (See No. 153.) Especially is this evident for water which increases in specific gravity from 0° to 4°, while its capillary height steadily decreases. (See No. 175.) He established the following relation between temperature and height of rise in tubes of 1 mm. radius:

|                 |                             |                                       |
|-----------------|-----------------------------|---------------------------------------|
| For Water,      | $h = 15.33215 - 0.0286396t$ | } where $t$ means degrees centigrade. |
| Sulfuric Ether, | $h = 5.3536 - 0.028012t$    |                                       |
| Olive Oil,      | $h = 7.4610 - 0.010486t$    |                                       |

- 174.** 1847. MORITZ, A. Leidenfrost's Versuch auf Glas. *Pogg. Ann.*, Vol. 72, p. 112.

With reference to an experiment by Emsmann, (see No. 146,) the author finds that *boiling* water when placed upon a watch glass which is heated from below, will always exhibit the phenomenon, even if a large quantity of water is taken.

- 175.** 1847. MORITZ, A. Ueber Coulomb's Verfahren, die Cohäsion einer Flüssigkeit zu bestimmen. *Pogg. Ann.*, Vol. 70, p. 74.

Employing the method of Coulomb (see No. 49,) the usefulness of which he emphasizes, he arrives at the conclusions,

- 1) That the adhesion of water attains a maximum at about 4° C. (Compare No. 173.)
- 2) That between 4° C and 34° C, the cohesion of water decreases more rapidly than the density.

- 176.** 1847. BUYS-BALLOT. Ueber den Einfluss der Temperatur auf die Synaphie. *Pogg. Ann.*, Vol. 71, p. 177-194.

Determined the weights necessary to separate disks from the surface of different liquids, (Water, Copper Sulfate and Sodium Sulfate,) making the observations at different temperatures while these liquids were in the process of cooling.

- 177.** 1847. HOLTZMANN, C. On the Cohesion of Water. *Pogg. Ann.*, Vol. 71, p. 563. See also *Lieb. Ann.*, Vol. 64, p. 147.

Confirms the formula obtained by Brunner for water (see No. 173.) arriving at almost the same values from an entirely different direction: Mechanical theory of heat.

- 178.** 1847. FRANKENHEIM. Ueber die Abhängigkeit einiger Cohäsionserscheinungen flüssiger Körper von der Temperatur. *Pogg. Ann.*, Vol. 72, p. 171-229.

Tables are given which show the relation between temperature, specific gravity, and some constants of capillarity for Water, Oil of Turpentine, Lemon Oil, and several other organic and inorganic substances.



- 179.** 1847. FRANKENHEIM. Ausdehnung einiger flüssiger Körper durch die Wärme. *Pogg. Ann.*, Vol. 72, p. 422-431.

The expansion by heat of the liquids spoken of in No. 178 is measured, and for each liquid the law of expansion is formulated.

- 180.** 1847. POISEUILLE. Recherches expérimentales sur le mouvement des liquides de nature différente dans les tubes de très-petits diamètres. *Ann. Chim. Phys.*, (3) Vol. 21, p. 76-110.  
See also *Lieb. Ann.*, Vol. 64, p. 129.

The former researches (see No. 162.) are here continued in order to ascertain, for physiological ends, whether an accelerating or a retarding influence is exerted on the flow of water or the serum of the blood through capillary tubes by the addition of weak solutions of acids, bases, salts, mineral waters and some pharmacal infusions.

- 181.** 1848. LIEBIG, J. v. *Researches on the Motion of the Juices in the Animal Body, and the effect of evaporation in plants.* Translated from the German Edition of 1848 by Wm. G. Gregory, 1850, Philadelphia.

Giving an historical summary, and adding his own experiments on osmosis, the author leads us to regard the motion of the juices in the animal and vegetable bodies as being the consequence of cutaneous or surface evaporation.

- 182.** 1848. PLATEAU, J. Ueber die Erscheinung bei einer freien und der Wirkung der Schwerkraft entzogenen Flüssigkeit. *Pogg. Ann.*, Erg. II, p. 249-285. From *Mém. Acad. Brux.*, Vol. 16.

Gives a complete review of his former experiments, with precautions necessary in order to succeed. (See No. 155.) Among other things he gives directions how to produce a Saturn like body, and sets forth an account of its formation.

- 183.** 1848. HENRY. Beobachtungen über Capillarität. *Pogg. Ann.*, Erg. II, p. 358. From *Proc. Am. Phil. Soc.*, Vol. IV. p. 176.

When a silver plated piece of copper is heated above a certain temperature the silver disappears, apparently by evaporation, but the silver surface may be restored by dipping the metal into a solution of Chlorid of Zinc. This is evidently a capillary phenomenon.

- 184.** 1848. KARSTEN, H. Das Bluten des Rebstocks unter den Tropen. (See No. 163.) *Pogg. Ann.*, Vol. 73, p. 19-40.

- 185.** 1848. VIERORDT, K. Beschreibung eines verbesserten Endosmometers. *Pogg. Ann.*, Vol. 73, p. 529.

In this endosmometer the membrane is placed vertically, and precautions are also taken to maintain constancy of pressure on both sides of the membrane, as the reading of the volumes passed, would be rendered inaccurate by the bulging of the membrane under one sided pressure. The author by means of his apparatus verifies Dutochet's result, that the rate of Osmosis of a solution is in direct proportion to its concentration.

- 186.** 1848. FRANKENHEIM. Veränderung der Höhe des Quecksilbers in Capillarröhren mit der Temperatur. *Pogg. Ann.*, Vol. 75, p. 229-244.

Observations regarding the influence of temperature upon the height of a column of Mercury were made by means of a U tube, one arm of which was much wider than the other. Fairly constant results were obtained, only at temperatures above 100° C, i. e., rise of temperature then increased the difference of level. At ordinary temperatures the measurements gave very irregular results.

- 187.** 1848. DANGER, T. P. Note sur la hauteur des ménisques que présente la surface du mercure contenu dans les vases en verre. *Ann. Chim. Phys.*, (5) Vol. 24, p. 501. See also *Pogg. Ann.*, Vol. 76, p. 297.

The author gives a table as the result of accurate observations wherein he records for each of 60 glass tubes varying in diameter from 1mm to 60mm, the total height of the mercurial meniscus in each tube, and the position of the intermediate level which would terminate a cylindrical meniscus of equal bulk. Hence this work gives us the data necessary to make accurate readings of mercurial heights in different tubes.

- 188.** 1848. WILSON, GEORGE. On some Phenomena of Capillary attraction observed with Chloroform, Bisulfuret of Carbon, and other liquids. *Jour. Chem. Soc.*, 1849, p. 174-180.

He calls attention to the property of the common surface of Chloroform and water, which is rounded out by acids and flattened by alkalies.

- 189.** 1848. SWAN, WILL. On certain Phenomena of Capillary attraction exhibited by Chloroform, the fixed Oils and other liquids. *Phil. Mag.*, (3) Vol. 33, p. 36-44.

Explains the phenomenon observed by Wilson (see No. 188.) by assuming a strong mutual surface attraction to exist between Chloroform and Caustic Potash, induced probably by their chemical affinity, and resulting in a strong horizontal force which is then modified by the action of the wall of the vessel.

- 190.** 1849. FRANKENHEIM. Note zu meinen Versuchen über die Veränderung der Synaphie mit der Temperatur. Remarks to this by H. Buff. *Pogg. Ann.*, Vol. 77, p. 445 and Vol. 78, p. 578.

Controversy with regard to an alleged error in Frankenheim's calculations. (See No. 178.)

- 191.** 1849. HAGEN, G. H. L. Ueber die Oberfläche von Flüssigkeiten. *Pogg. Ann.*, Vol. 77, p. 449-467. From *Abh. Berl. Acad.*, 1846, p. 1-16. Also see *Ber. Berl. Acad.*, 1846, p. 154-158.

Determined the surface tension (see No. 171.) of fresh and stale water, Gum and Lye water, also Olive Oil, Alcohol and Mercury, making use of three distinctly different methods, viz: Measuring the height of rise between parallel plates, determining the weights of drops formed at a surface of known dimensions and determining the weights necessary to separate adhesion plates from the liquids in question.

The surface tension of Mercury was found to be 0.0818 grms., this being seven times as much as that of clean water. It further resulted, that gum water has the same, but lye water a considerably lower surface tension than pure water, and that the surface tension decreases perceptibly for Water and for Mercury upon standing.

- 192.** 1849. JOLLY, PH. Experimental-Untersuchungen über Endosmose. *Pogg. Ann.*, Vol. 78, p. 261-271.

Introduces the notion of Endosmotic Equivalents, these being the quantity of water exchanged for the passage in the opposite direction of a given amount of the dissolved substance. These equivalents he claims to be characteristic for each substance. (See No. 193.) The measurements were taken by weight, not by volume.

- 193.** 1849. LUDWIG, C. Ueber die endosmotischen Aequivalente und die endosmotische Theorie. *Pogg. Ann.*, Vol. 78, p. 307-326.

He finds that each salt has its own specific equivalent, but this is not, as Jolly claims, (see No. 192.) a constant quantity for each substance, but depends on the degree of concentration of the solutions.

- 194.** 1850. BRUNNER, C. Einfluss des Magnetismus auf die Cohäsion von Flüssigkeiten. *Pogg. Ann.*, Vol. 79, p. 141.

The discovery by Faraday of the influence of magnetism upon polarized light suggested to the author the possibility, that magnetism might also influence cohesion and especially effect capillary phenomena. But experiments carried out by MOUSSON with strong electro magnets and capillary tubes with water or a solution of an iron salt gave a negative result.

- 195.** 1850. SCHNAUSS, J. Neue Versuche mit dem Leidenfrost'schen Phänomen. *Pogg. Ann.*, Vol. 79, p. 432.

Describes the phenomenon observed before by Laurent, (see No. 141,) viz., the formation of symmetrical figures. He likewise mentions the fact that the number of the protrusions is always even. Their number generally increases when the heat increases. He likens the phenomenon to the vibrations sometimes produced by sound.

- 196.** 1850. GRAHAM. On the diffusion of liquids. *Phil. Trans.*, 1850, p. 1-45. Also see No. 198.

Numerous detail experiments, the first that were made systematically without the use of a membrane, lead to the following conclusions:

1)—Diffusion, like volatility, is a property of fundamental character, having even a larger scope.

2—A connection exists between diffusibilities and solution densities, relations between diffusibilities being apparent for equal weights, not for molecular weights.

3)—There is an analogy between isomorphism and diffusion, inasmuch as substances can be divided into classes of equidiffusive bodies; although they sometimes divide isomorphous groups.

- 197.** 1850. GRAHAM, TH. Supplementary observations on the Diffusion of Liquids. *Phil. Trans.*, 1850, p. 805-836. Also see No. 198.

The main aim of this and the former paper (see No. 196,) was to supply accurate data regarding diffusibilities of as many soluble substances as possible. Close similarity, possibly equality exists in the diffusive power of certain classes of substances, e. g., the Chlorids and Nitrates of the same metal. The Hydrochlorates of Strychnine and Morphine are found to be equidiffusive.

- 198.** 1850. GRAHAM, TH. Recherches sur la diffusion des liquides, *Ann. Chim. Phys.*, (3) Vol. 29, p. 197-229.

Résumé of Nos. 196 and 197.

- 199.** 1851. GRAHAM, TH. On the diffusion of liquids. *Phil. Trans.*, 1851, II, p. 483-494.

This memoir treats of the diffusion of the Potassium and Sodium Salts only. In nine pairs of these salts the Potassium Salts diffused more rapidly than the corresponding Sodium Salts, and in the case of Rochelle Salt, even chemical decomposition took place, inasmuch as diffusion yielded three times more Tartrate of Potassium than of Sodium.

- 200.** 1851. PLATEAU, J. Experimentelle und theoretische Untersuchungen über die Gleichgewichtsfiguren einer flüssigen Masse ohne Schwere. *Pogg. Ann.*, Vol. 82, p. 387-405. From *Ann. Chim. Phys.*, (3) Vol. 30, p. 203.

In continuance of his fundamental experiment (see No. 182,) the author produces additional figures of equilibrium of a liquid mass freed from the influence of gravitation, as cylinders, cubes and polyhedra, by introducing wire frames of proper form into this mass. As the shape of these figures may be calculated from the capillary theory, they form an excellent means to test the accuracy of the latter.

Finally speaks of the spontaneous conversion of a liquid cylinder into drops, and in connection therewith gives the theory of the form of a liquid jet issuing from a vessel, which subject had been experimentally investigated by SAVART.



- 201.** 1851. PERSON, C. C. Ueber die Kraft, welche beim Leidenfrostschen Versuch den Tropfen trägt. *Pogg. Ann.*, Vol. 84, p. 274.  
See also *Comptes Rendus*, Vol. 31, p. 900 and Vol. 32, p. 463.

He holds that it is the tension of the vapors that supports the drop, and in order to prove it experimentally, he dips the upper end of a long S tube into the spheroidal liquid so as to touch the bottom of the red hot vessel. The other arm contains water which shows a difference of level equal to the height of the fluid in the red hot dish.

- 202.** 1851. SIMON, DE METZ. Recherches sur la Capillarité. *Ann. Chim. Phys.*, (3) Vol. 32, p. 1-41.

Some results of his experiments are as follows: The law of rise in inverse ratio to the diameter, does not hold good for all diameters. The height to which a liquid rises between parallel planes, does not stand in the proportion of 1:2, compared with the rise in a capillary tube of a diameter equal to the distance between the plates. He claims the ratio to be 1:3.1416, the same as between diameter and circumference of a circle. Temperature remarkably influences the phenomena of rise in capillary tubes, as the same tube placed in water successively at 0° and at 100°, gives in both cases the ratio of 4:3.

- 203.** 1852. TYNDALL, JOHN. On Molecular Action. *Brit. Assoc. Rep.*, 1852, (2) p. 20.

The author discovers the fact that the conductivity of wood for heat is not uniform in all directions, but is graded in magnitude along three axes rectangular to one another, whose location is determined by the structure of the wood. The same axes also indicate the gradations existing similarly for the forces of cohesion and of fluid permeability.

- 204.** 1852. BEDE. Mémoire sur l'ascension de l'eau et la dépression du Mercure dans les tubes capillaires. *Bull. Acad. Belge*, (2) Vol. 19, p. 470.

He finds that Jurin's law (see No. 16,) agrees fairly well for mercury in tubes of less than 1mm. diameter, but as to the rise of water, he sustains Simon's results, (see No. 202.) finding that this fluid rises somewhat higher than the theory demands. He explains that discrepancy between Laplace's Theory and the experiment results from failure of the former to take into account the thickness of the liquid film, which is presumed to coat the inner walls of the tube, and to which the aqueous column adheres.

- 205.** 1852. DESAINS, E. Anwendung der Theorie der Capillarphänomene. *Pogg. Ann.*, Vol. 86, p. 492. From *Comptes Rendus*, Vol. 34, p. 765.

Desains calculated the height of the meniscus for Mercury in tubes of different diameters by means of a formula given by Laplace, and the results were strikingly coincident with those obtained experimentally by Danger. (See No. 187.) He also calculated and verified experimentally the same values for the meniscus of water in glass tubes.

- 206.** 1852. MUELLER. *Lehrbuch der Physik und Meteorologie*. 1853. Vol. I, p. 97-110. Capillarität.

- 207.** 1853. SEGUIN, d. A. Theorie der Cohäsion und Trennung der materiellen Teilchen oder Molecüle der Körper. *Pogg. Ann.*, Vol. 88, p. 432. See also *Comptes Rendus*, Vol. 37, p. 704-709.

Considers the mass molecules consisting of rows of much smaller molecules each of which, although finite, is small beyond conception. Then the last atoms are as far distant from one another, as the celestial bodies are in space, and Newton's law is sufficient to express the attraction, that is, the cohesion, existing between them. (See No. 60.)

- 208.** 1853. SEYFFER, O. Experimentelle physikalische Mittheilungen. *Pogg. Ann.*, Vol. 70, p. 570.

Describes a form of apparatus suitable to produce Plateau's phenomena (See No. 182.) Also discusses the observation made by Schnauss, regarding the symmetrical vibrations in Leidenfrost's experiment. (See No. 195.)

- 209.** 1853. SIRE. Erscheinungen beim Auftropfen gewisser Flüssigkeiten auf die Oberfläche eines Aethers. *Pogg. Ann.*, Vol. 90, p. 626. From *Comptes Rendus*. Vol. 37, p. 667.

One drop of glacial Acetic Acid when placed upon ordinary Sulfuric Ether at  $32^{\circ}$  C, in a tube, 2–3 cms. wide, is seen to float, and swell to six times its bulk. Nitric Acid shows the phenomenon most strikingly, swelling to twelve times its bulk.

- 210.** 1854. DUPREZ. Sur un cas particulier de l'équilibre des liquides. *Ann. Chim. Phys.*, (3) Vol. 42, p. 500.

The phenomenon of a large body of water being suspended from an inverted tumbler when a disk of paper is carefully placed against its rim, is in principle the same as that manifested in much narrower tubes where no paper need be used. In both cases the pressure of the air counteracts the weight of the aqueous column, but only under the condition that the free surface is one of stable capillary equilibrium. Such a condition being better insured in narrow tubes than in a wide glass, the use of a paper disk is necessary in the latter case, in order to prevent any deformation of the surface, especially at the edge of the glass, where the capillary equilibrium is most liable to be disturbed.

- 211.** 1854. GRAHAM. On Osmotic Force. *Phil. Mag.*, (4) Vol. 8, p. 151. Also see *Phil. Trans.*, 1854, p. 177-228, and *Ann. Chim. Phys.*, (3) Vol. 45, p. 5-90.

Osmotic force is pronounced to be that peculiar power which causes the strong current of water to flow into different salt solutions separated from it by a membrane, as for example in Dutochet's Endosmometer. Neither diffusion, still less capillarity is said to sufficiently explain the enormousness of that bulk of water exchanged for only minute amounts of salt. A number of interesting experiments tend to show that the phenomenon is mainly that of electrochemical action, whereby the membrane undergoes a gradual decomposition. The author finally points out the important function of the osmotic force in the plant and animal organisms.

- 212.** 1855. BUNSEN, R. W. Ueber das Gesetz der Gasabsorption. *Lieb. Ann.*, Vol. 93, p. 116. See also *Phil. Mag.*, (4) Vol. 9, p. 116-130 and 181-201.

Theoretical considerations and experimental researches relative to the absorption of gases by water.

- 213.** 1855. THOMSON, JAMES. On certain curious motions observable at the surfaces of wine and other alcoholic liquors. *Phil. Mag.*, (4) Vol. 10, p. 330-333.

The well known phenomenon commonly called the "tears of strong wine," is due to the same influence as that which causes a thin sheet of water to recede from a drop of Alcohol with which it is brought in contact. This results from the difference in surface tension between Water and Alcohol.

The author argues that the "tears" are produced by contact between the strong alcoholic liquid in the wine glass, and the fluid running down the sides, which has become more aqueous by evaporation. In support of this argument he adduces the fact that the "tears" do not form in corked vessels.

- 214.** 1855. FICK, AD. Ueber Diffusion. *Pogg. Ann.*, Vol. 94, p. 59-86.

Fick was the first to formulate the data of diffusion into a law, which was later verified by H. F. Weber, viz:

The quantity of salt which diffuses in the unit of time between two elements of space filled with differently concentrated solutions of the same salt, is directly proportioned to the difference of concentration and inversely proportioned to the distance of the elements from one another.

- 215.** 1855. BEER, A. Ueber die Oberfläche rotirender Flüssigkeiten, insbesondere über den Plateau'schen Rotationsversuch. *Pogg. Ann.*, Vol. 96, p. 1-18-210-254.

Establishing and discussing a mathematical expression for Rotation figures as obtained in Plateau's experiment. (See No. 182.)

- 216.** 1855. LHERMITE. Recherches sur l'endosmose. *Ann. Chim. Phys.*, (3) Vol. 43, p. 420-431.

Two liquids miscible with each other, (e. g., Alcohol and Water,) and separated by a thin stratum of a third, (e. g. Castor Oil,) that has affinity only for one of those, combine after some time, forcing the intermediate layer on top. This principle the author applies to the phenomenon of endosmosis. He also shows that water passes through a porous diaphragm into alcohol under ordinary conditions, but the reversed motion takes place when the diaphragm is previously saturated with Castor Oil.

- 217.** 1856. RIJKE, P. L. Electricitätserregung, welche man beobachtet wenn eine Flüssigkeit den sphäroidalen Zustand verlässt. *Pogg. Ann.*, Vol. 98, p. 500.

Describes the conditions under which electrical phenomena exhibited in Leidenfrost's experiment, are most pronounced. The liquids used were Water, Acids, Alkalies and Salts.

- 218.** 1856. WOLF, C. Ueber die Temperatur, bei der die Flüssigkeiten die sie einschliessenden Gefässe zu benetzen aufhören. *Pogg. Ann.*, Vol. 98, p. 643. See also *Comptes Rendus*, Vol. 42, p. 968.

Brunner's formula (see No. 173.) indicates that for Sulfuric Ether the capillary height would be 0 at a temperature of  $191^{\circ}$  C. Wolf now observed, that upon heating a sealed glass tube enclosing a capillary tube and some Ether, the capillary height gradually diminished and became 0 at about  $190$ - $191^{\circ}$  C. The curvature of the meniscus became more and more flat, and at the aforementioned temperature level. Upon further heating he observed even depression of the Ether column and a convex curvature of the meniscus. At  $200^{\circ}$  C the whole liquid became converted into vapor. (See No. 96.) Upon cooling, the same phenomena took place in reversed order. (Compare DRION, No. 239.)

- 219.** 1856. JAMIN, J. Ueber die Endosmose der Gase. *Pogg. Ann.*, Vol. 99, p. 327-329. From *Comptes Rendus*, Vol. 43, p. 234.

Repeating Magnus' Experiments (see No. 105,) he makes use of a porous cell to which he gives a thin coating of collodium. By connecting the closed cell with a water reservoir by means of a long glass tube, and filling the cell with Hydrogen gas, the process of diffusion will cause the water to rise in the tube as high as  $2\frac{1}{2}$  meters in 20 seconds.

- 220.** 1856. SCHMIDT, WILLIBALD. Versuche über Filtrationsgeschwindigkeit verschiedener Flüssigkeiten durch tierische Membran. *Pogg. Ann.*, Vol. 99, p. 337-388.

Studied the influence of pressure and of temperature upon the velocity of filtration of different liquids through animal membranes.

- 221.** 1857. DESAINS, E. Recherches sur les phénomènes capillaires. *Pogg. Ann.*, Vol. 100, p. 356. From *Ann. Chim. Phys.*, (3) Vol. 51, p. 385-445.

Desains, endeavoring to verify Laplace's theory, (see No. 64,) determined the dimensions of a drop of Mercury on glass, the height to which water rose in glass tubes and between glass plates, and found a close coincidence between theory and experiment. However Hagen's suggestion (see No. 171.) to consider the meniscus in capillary tubes as a hemi-ellipsoid, is found to approach the experimental results better than Laplace's assumption of a hemispherical meniscus.

- 222.** 1857. BEER, A. Ueber die Plateau'schen Versuche mit Flüssigkeiten, welche der Wirkung der Schwerkraft entzogen sind. *Pogg. Ann.*, Vol. 100, p. 458.

Discusses from a mathematical point of view, the changes that may take place in the form of a liquid cylinder or of a globe, rotating around an axis.



- 223.** 1857. SIMMLER, TH. and WILD, H. Neue Methode zur Bestimmung der bei der Diffusion einer Salzlösung in reine Lösungsmittel auftretenden Constanten. *Pogg. Ann.*, Vol. 100, p. 217 and 660.

Mathematical deductions for which data were obtained by placing the salt solution against a water column in suitable vessels, and determining the change in concentration both by gravimetric analysis and by optical methods. (See No. 294.)

- 224.** 1857. WOLF, C. Einfluss der Temperatur auf die Erscheinungen in Haarröhren. *Pogg. Ann.*, Vol. 101, p. 550-576 (A) and Vol. 102, p. 571 (B). See also *Ann. Chim. Phys.*, (3) Vol. 49, p. 230-281.

A)—Gives an historical résumé of previous investigations regarding the relations between Temperature and Capillarity.

B)—His experiments corroborate Brunner's conclusions that the decrease of capillary height with temperature is more rapid than that of density, (see No. 173,) which fact contradicts some phases in Laplace's theory. (See No. 64.) The interesting behavior exhibited by Ether in a capillary tube, at high temperature in closed vessels, (see No. 218,) leads him to view the phenomenon of rise and depression, as the result of a general law of continuity.

- 225.** 1857. POGGENDORFF. Note on earliest history of Capillarity. *Pogg. Ann.*, Vol. 101, p. 551. See No. 1.

- 226.** 1857. PLATEAU, J. Transformation des flüssigen Cylinders. *Pogg. Ann.*, Vol. 102, p. 320.

Plateau calls attention to the fact that some of Beer's former theoretical deductions (see No. 222,) were not borne out by experiment.

- 227.** 1857. WERTHEIM, G. Ueber die Capillarität. *Pogg. Ann.*, Vol. 102, p. 595. See also *Comptes Rendus*, Vol. 44, p. 1024.

In order to test Laplace's theory experimentally, he measured the bulk of liquid which rose spontaneously under various conditions. He observed, for example, that with the same liquid a constant bulk rises between two parallel plates, irrespective of the distance between the plates.

- 228.** 1857. WILLIGEN, VAN DER. Ueber die Constitution der Seifenblasen. *Pogg. Ann.*, Vol. 102, p. 629.

Observed in soap bubbles a distinct line of demarcation between the black zone on top of the bubble and the zone of colors below. He concludes that a soap bubble consists of an interior aqueous non-refractive layer, which supports a layer of fatty substance, the latter agent being the refractive medium, that gives rise to the colors. Striving to sink to the lower part of the bubble, it leaves the aqueous black skin on top and forms a distinct boundary zone.

- 229.** 1857. VALSON, ALPH. Sur la théorie des phénomènes capillaires. *Comptes Rendus*, Vol. 45, p. 10.

Verifies BERTRAND's observation (*Journal de Liouville*, June, 1846,) that the total mass of a cylindrical column elevated by capillarity, is the same as when bubbles of air are interposed. He further considers various phases of capillary phenomena, for example, the time required for a liquid capillary column to assume its state of equilibrium. (Compare No. 330.)

- 230.** 1857. VALSON, ALPH. Application de la théorie de l'action capillaire à la recherche des variations des actions moléculaires dans les liquides. *Comptes Rendus*, Vol. 45, p. 101.

Observed the fact that in making mixtures of miscible liquids, and changing the proportions of the constituents, these variations are strikingly indicated by corresponding variations in the capillary rise of the resultant liquids. This being especially the case for mixtures of Alcohol and Water, the construction of a sensitive Alcoholometer on this principle is suggested. (See No. 56.)

- 231.** 1857. DESAINS, E. Ueber das capillare Aufsteigen des Wassers zwischen parallelen Platten. *Pogg. Ann.*, Vol. 102, p. 601.  
See also *Comptes Rendus*, Vol. 45, p. 265.

Denying the correctness of Simon's statement, (see No. 202,) also upheld by Wertheim, (see No. 227,) that water rises between parallel plates about  $\frac{1}{2}$  as high as in a capillary tube whose diameter is equal to the distance of the plates, he brings additional experiments to prove that the proportion is exactly 1:2.

- 232.** 1857. GILBERT. Ueber die Theorie der Capillarphänomene. *Pogg. Ann.*, Vol. 102, p. 605. See also *Comptes Rendus*, Vol. 45, p. 771.

From a formula given by Gauss, (see No. 115,) he deduces the proportion of  $1:3.1416/2$  for the height to which water rises between two parallel plates and in capillary tubes of a diameter equal to their distance. (Compare Nos. 202 and 231.)

- 233.** 1858. DUBOIS-REYMOND P. Ueber die Erscheinungen, welche die Ausbreitung von Flüssigkeiten auf Flüssigkeiten hervorruft. *Pogg. Ann.*, Vol. 104, p. 193-234.

The case of Alcohol expanding on Oil and that of Oil expanding on water, are types of different modes of expansion. The former is stationary, that is, it extends only over a limited area, leaving a nucleus of Alcohol of a certain thickness in its center. The second is unlimited, the oil spreads rapidly until the central drop is dissipated over the aqueous surface, then if a sufficient amount of oil is employed, the film contracts into a number of oily drops. These conditions in connection with the Newton's rings observable in these phenomena, are here investigated.

- 234.** 1858. QUINCKE, G. Ueber die Capillaritätsconstanten des Quecksilbers. *Pogg. Ann.*, Vol. 105, p. 1-48.

Quincke, seeking to corroborate Laplace's and Young's capillary theories, (see Nos. 63 and 64,) which emphasize the constancy of angle of contact between liquid and solid, attempted to determine the angle of contact between mercury and glass. But both indirect and direct measurements, (the latter on the principle of triple reflection of light,) proved that the angle of contact of mercury for glass is very inconstant, probably owing to changes in the condition of both mercury and glass. The angle varied from  $38^\circ$  to  $42^\circ 54'$ , in one series of determinations.

- 235.** 1858. QUINCKE, G. Ueber die Verdichtung von Gasen und Dämpfen an der Oberfläche von Flüssigkeiten. *Pogg. Ann.*, Vol. 105, p. 326-353.

Gives an interesting review of former experiments by SAUSSURE, MOSER, WAIDLE, KARSTEN and others, illustrating the property of solid bodies to absorb gases on their surfaces, and their behavior towards heat, light and electricity. He comes to the conclusion that the absorption is in proportion to the density and the surface of the solid body, provided the same law of attraction holds good on both the surface and the inside of the solid.

- 236.** 1858. BEDE. Recherches sur la capillarité. *Bull. Acad. Belge*, (2) Vol. 16, p. 405-411.

Measured the depression of Mercury in glass tubes by means of an electrical arrangement, but made the readings only after prolonged standing, which is now known to affect the surface tension of Mercury very materially. He also experimented on the depression of melted lead and tin in capillary spaces. (See No. 26.)

- 237.** 1859. SORBY. On the freezing point of water in capillary tubes. *Phil. Mag.*, (4) Vol. 18, p. 105.

The investigation was suggested by the behavior of fluid enclosures in quartz. In tubes of 1-4 to 1-40 inch in diameter, water did not freeze at  $-5^{\circ}$  C, but froze at  $-6^{\circ}$  C. In tubes of 1-100 inch, water did not freeze at  $-11^{\circ}$  C, but froze at  $-13^{\circ}$  C. Between 1-200 and 1-300 inch, water did not freeze at  $-15^{\circ}$ , even when the tube was shaken, but froze at  $-17^{\circ}$ , when the tube was kept perfectly quiet.

- 238.** 1859. LANGBERG, CH. On the influence of capillary attraction upon the Hydrometrical measurement of the specific gravity of liquids. *Phil. Mag.*, (4) Vol. 18, p. 113, From *Pogg. Ann.*, Vol. 106, p. 299.

The author observed differences of  $\frac{1}{2}$  to 1% in the indications of Alcoholometers, according to whether they were tested by means of fluids of known strength, or by BRISSON'S method, (i. e., calculating the specific gravity of alcohol from the weight required to sink the instrument in water to the same mark to which it sank in the alcohol to be examined.) He concludes that the capillary fluid wall which adheres to the stem, increases the weight of the apparatus, thereby causing a false indication. Calculates the magnitude of this influence and finds the values closely approach the discrepancy before cited, (See No. 73.)

- 239.** 1859. DRION, CH. Expériences relatives à l'influence de la chaleur dans les phénomènes capillaires. *Ann. Chim. Phys.*, (3) Vol. 58, p. 221.

Operating on Sulfuric Acid, Ethyl Chlorid and Sulfuric Ether, the author confirms in part only Wolf's observations. (See No. 218.) He finds that the curvature of the liquid decreases with rising temperature, but becomes a plane only at the moment of vaporization. He observed a depression of the inner liquid below the outside surface but not a convex meniscus. Hence he ascribes this depression to a sudden manifestation of the dilatibility which the outer liquid possesses to a considerable degree near its point of volatilization.

- 240.** 1859. PLATEAU, J. Title as in No. 183. 4th series. *Pogg. Ann.*, Vol. 107, p. 394-409.

Continuation of the studies of Rotation figures. By the rotation of solid bodies of definite shapes in Oil, he produces three new classes of figures which he calls UNULOIDES, CATENOIDES and NODOIDS.

- 241.** 1860. WRIGHT, T. ST. On the behavior of Mercury as an electrode. *Phil. Mag.*, (4) Vol. 19, p. 129.

Results: 1) So soon as chemical affinities are excited in the galvanic processes there takes place at the same time an increased intensity of the attraction of surfaces (that is, of capillary attraction.) 2) The connexion which has been supposed to exist between capillary or surface attraction and chemical affinity, receives from this a notable confirmation.

- 242.** 1860. JAMIN, J. On the Equilibrium and Motion of Liquids in porous bodies. *Phil. Mag.*, (4) Vol. 19, p. 204. From *Comptes Rendus*, Vol. 50, p. 172, 311, 385.

When a capillary tube contains a great number of air bubbles, it can sustain a very high column of water, the height of which is dependent upon the number of the bubbles. This in connection with surface evaporation will sufficiently explain the rise of sap in plants. (See Nos. 105 and 163.)

- 243.** 1860. BEDE. Recherches sur la capillarité. *Bull. Acad. Belg.*, (2) Vol. 10, p. 47-55.

Repeated experiments show that the product of the radius of the capillary tube into the height of the column increased by  $\frac{1}{3}$  of the radius, is about constant for diameters from 2 mm. down to 0.1 mm. (See No. 204.) Also retraces his former theory regarding the influence of the adhering film.



- 244.** 1860. MENDELEEFF. Sur la cohésion moléculaire de quelques liquides organiques. *Comptes Rendus*, Vol. 50, p. 52.

Algebraically combining molecular weight with an expression for cohesion, he finds for a series of organic substances like Alcohols, Acids and Ethers certain regularities for this MOLECULAR COHESION, as he calls it. For example, the molecular cohesion of homologous bodies increases by a fairly constant number with the molecular weight. Isomeric bodies possess equal molecular cohesion.

- 245.** 1860. MENDELEEFF, D. Sur la cohésion de quelques liquides et sur le rôle de la cohésion moléculaire dans les réactions chimiques des corps. *Comptes Rendus*, Vol. 51, p. 97.

Continuing his former researches, (see No. 244,) he finds the increase in molecular cohesion to vary from 50 to 90 for each  $\text{CH}_2$  of an homologous series. He attributes to molecular cohesion a dominating influence upon chemical reactions, inasmuch as he claims a tendency to exist towards forming substances of highest molecular cohesion.

- 246.** 1860. HAGENBACH. Ueber die Bestimmung der Zähigkeit einer Flüssigkeit durch den Ausfluss aus Röhren. *Pogg. Ann.*, Vol. 109, p. 385-426.

Defining "viscosity" as the force necessary to move a fluid layer of the thickness of a molecule and of the unit of surface in one second with uniform velocity along an adjoining layer for a distance of 2 molecules, he finds the viscosity of Water at  $10^\circ \text{C} = 0.12351$  grams, using a meter square as the unit of surface. Viscosity decreases considerably with rising temperature. Through purely mathematical reasonings he arrives at exactly the same formula which Poiseuille had found experimentally for the flow of a liquid through capillary tubes. (See No. 162.)

- 247.** 1860. SCHUMACHER, W. Ueber Membrandiffusion. *Pogg. Ann.*, Vol. 110, p. 337-370.

Experiments on the diffusion of Acids and Salts into water, by making use of tubular membranes of Collodium and taking the precaution of maintaining equal pressure on both sides of the membrane. The author corroborates Ludwig's results (see No. 193,) to the effect that the notion of definite Endosmotic Equivalents cannot be upheld. With Oxalic Acid the "endosmotic equivalent" is very considerable in very dilute solution. The reverse is the case with Sodium Chlorid. Rise in temperature speeds the osmotic action.

- 248.** 1860. BOUTIGNY. Sur l'état sphéroïdal de la matière. *Comptes Rendus*, Vol. 50, p. 675.

The spheroidal state of matter is not confined to liquids alone, for solid bodies, like Ammonium Chlorid, Tallow, Corrosive Sublimate, Camphor, Iodine, etc., may also exhibit that phenomenon. The author calls especial attention to the fact that small pieces of ice placed upon the back of the hand, produce in quick succession two distinctly different sensations, first that of heat,  $98^\circ \text{C}$ , and then of cold,  $0^\circ \text{C}$ . Both temperatures are observable by means of the thermometer, when using larger quantities of ice.

- 249.** 1861. TATE, T. On certain peculiar forms of capillary action. *Phil. Mag.*, (4) Vol. 21, p. 254-257.

Demonstrates the capillary action of small openings in the walls of cylindrical glass vessels which hold a column of water suspended above a water surface. The height which can thus be supported notwithstanding the opening, is equal to the height to which water would rise in a capillary tube of the same diameter as that of the hole. (Compare No. 16.)

- 250.** 1861. WERTHEIM, G. Mémoire sur la Capillarité. *Ann. Chim. Phys.*, (3) Vol. 63, p. 129-193. (Submitted to the Acad., 1854.)

He compares the capillary action of liquids on plates and the outside surface of cylinders. The aim is to find in each case the relations existing between the nature of the solid and the liquid on one hand, and the volume of liquid which is raised or depressed and the form of its surface and its contour on the other. He largely employs melted wax which after solidification affords a convenient means of measuring the quantities in question. (See No. 227.)

- 251.** 1861. MENDELEEFF. Ueber die Ausdehnung der Flüssigkeiten beim Erwärmen über ihren Siedepunkt. *Lieb. Ann.*, Vol. 119, p. 1.

For Ether, Alcohol and Water, also for Benzine and Silicon Chlorid, he observed that these liquids, when heated in closed glass tubes above their boiling point, follow the same laws of expansion that hold good for temperatures below their boiling point. The latter have been empirically established by KOPP.

- 252.** 1861. DESAINS, E. Lettre sur une expérience de M. Wertheim sur la Capillarité. *Ann. Chim. Phys.*, (3) Vol. 63, p. 447-458.

Reports the result of an experiment made by Mr. Wertheim upon Desain's suggestion. Accordingly the height of rise of water between glass plates agrees closely with the value calculated from Laplace's theory, which tends to disprove Simon's conclusion. (See Nos. 202 and 227.)

- 253.** 1861. GRAHAM, TH. Liquid diffusion applied to Analysis. *Phil. Trans.*, 1867 p. 183-224. Also see *Phil. Mag.*, (4) Vol. 23, p. 204-223, 290-306, 368-379, (1862.)

In this famous treatise the author expounds the principle of Dialysis. Establishes the distinction between Crystalloids and Colloids, based on the marked difference in their diffusibilities into water, which affords a means of separating both classes of substances. (Dialysis.)

The author shows that crystalloids will not only dialyze into water, but also into colloids, like Jelly, etc., while Caramel for example, refuses to pass into this medium. Gives minute directions how to prepare inorganic soluble colloid substances, like soluble Silicic Acid, Alumina, Peroxide of Iron, Prussian Blue, etc., and also how to prepare organic colloids by Dialysis, like Tannin, Gum, Dextrin, etc.

- 254.** 1861. GRAHAM, TH. On liquid transpiration in relation to chemical Composition. *Phil. Trans.*, 1861, p. 373-386. See *Phil. Mag.*, (4) Vol. 26, p. 409-434.

Defining Transpiration as the passage of liquids under pressure through a capillary tube, he confirms the observation made by Poiseuille, (see No. 162.) that a definite hydrate of alcohol, corresponding to the (modern) formula of  $C_2H_6O \cdot 3H_2O$ , requires more time for transpiration under constant pressure than if either water or alcohol is added to it. Graham furthermore finds that the same phenomenon, that is, a maximum of retardation, takes place in the transpiration of certain mineral and organic acids at those points where the composition corresponds to definite hydrates of the acids.

- 255.** 1861. TOMLINSON, CH. On the action of certain vapors on films. On the motion of Creosote, Benzoic Acid, Camphor, etc., on Water. *Phil. Mag.*, (4) Vol. 22, p. 111-120. See also *Phil. Mag.*, (4) Vol. 27, p. 528-539, (1864.) *Chem. News*, Vol. 8, p. 28, 37 and 123, (1863.) *Chem. News*, Vol. 10, p. 25, (1864.)

Numerous experiments similar in principle to those instituted by previous workers. (See Nos. 52, 54, 57 and 233.)

- 256.** 1861. TOMLINSON, CHARLES, On the Cohesion figures of liquids. *Brit. Assoc. Rep.*, 1861, (2) p. 93. Also see *Phil. Mag.*, (4) Vol. 22, p. 249-261. *Phil. Mag.*, (4) Vol. 23, p. 186-195, (1862.) *Pharm. Journal*, (1864) p. 387 and 495.

When a drop of an independent liquid, (that is, not a solution, e. g. oil of lavender,) is placed upon another, e. g. Water, a struggle takes place between them, giving rise to beautiful figures, which the author calls cohesion figures.

He thinks some of these figures are characteristic of the substances producing them, and suggests the applicability of this phenomenon for the detection of adulteration in oils. Olive Oil, for example, may be recognized in Oil of Cloves by the beautiful iridescence which it imparts to cohesion figures on water.

- 257.** 1861. LEROY, M. L. Testing pharmaceutical preparations by means of blotting paper. *Amer. Journ. Pharmacy*, Vol. 33, p. 93. Editorial comment upon this suggestion. (See No. 259.)

- 258.** 1861. ECKHARDT. Ueber die Depression des Quecksilbers im Barometer. *Pogg. Ann.*, Vol. 112, p. 336.

The depression of the Mercury in barometric tubes depends conjointly on the width of the tube, and the radius of curvature of the meniscus. In a siphon barometer the depression of Mercury is equalized only, if the menisci in both arms of the barometer have also the same radius of curvature.

The author gives a formula by means of which the correct height can be calculated if diameter and height of meniscus are known.

- 259.** 1861. SCHOENBEIN, C. F. Ueber einige durch die Haarröhrchenanziehung des Papiers hervorgebrachte Trennungswirkungen. *Pogg. Ann.*, Vol. 114, p. 275.

He demonstrates the differentiating influence which paper exerts upon solutions of various kinds, e. g., Alkalies, Acids, Salts and certain vegetable dye stuffs. In almost every case water travels much faster than the substance held in solution by it. (See No. 271.)

- 260.** 1861. PLATEAU, J. Title as in No. 182. 5th series. *Pogg. Ann.*, Vol. 114, p. 597-608.

His study of thin liquid films, e. g., soap bubbles, demonstrates the pressure which the film surface exerts upon the air enclosed. Calculates that the upper limit of the radius of the sphere of molecular action is 1-17000 mm.

- 261.** 1862. GUINET, ERNEST. Phenomena of Transport through porous bodies. Application to direct Analysis. Dialysis. *Comptes Rendus*, 1862. See also *Phil. Mag.*, (4) Vol. 25, p. 80, (1863.)

With regard to Graham's researches on Dialysis, the author suggests to substitute for the parchment membrane a porous vessel of pipe-clay. This medium allows the dialyzing of solutions which would destroy parchment. e. g., solution of Cellulose in ammoniated Copper Salts.

He explains the phenomena of dialysis by presuming the porous medium to act as a sieve, which excludes substances of high molecular volume (as Colloids) and, with regard to crystalloids, allows more ready passage to those with smaller molecular volume. Sulfur passes more readily than Iodine, when both are employed in  $\text{CS}_2$  Solution.)

- 262.** 1862. BEDE, EMILE. Recherches sur la liaison entre les phénomènes de Capillarité et d'Endosmose. *Bull. Acad. Belg.*, (2) Vol. 13, p. 111.

Water, by evaporating from the surface of an animal membrane (see experiment by Magnus. No. 1053) produces a suction of 79 mm. Mercury in 23 days. Alcohol, Ether, and Oil of Turpentine have little or no such action. Salt solutions, if concentrated, produce less suction than dilute solutions; thus concentrated solutions penetrate animal membranes with more difficulty than dilute solutions. Endosmosis is pronounced to be the result of the different tendencies which are inherent in the fluids existing at both sides of the membrane to penetrate the latter; such tendency being measurable by a column of mercury elevated by suction, as illustrated in the experiment of MAGNUS.

- 263.** 1862. BEDE, E. Recherches sur la Capillarité. *Bull. Acad. Belg.*, (2) Vol. 14, p. 344-349.

Seeks to verify by experiment some theoretical conclusions regarding the height of wide bubbles of air under horizontal glass plates within liquids of various nature, likewise the equilibrium of drops of various liquids between glass plates which form an angle with each other. In the former case, Water and Ammonia present the exceptional phenomenon of causing a maximum and afterwards a minimum height of the air bubble.



- 264.** 1862. WIENER, CHR. Erklärung des atomistischen Wesens des tropfbar-flüssigen Körperzustandes, und Bestätigung desselben durch die sogenannten Molecularbewegungen. *Pogg. Ann.*, Vol. 118, p. 79-93.

The hypothesis is advanced that all substances consist of atoms of matter, attracting one another. Interspersed with ether atoms, repelling one another and being repelled by the atoms of matter. These two kinds of atoms forming two different systems of vibrations; in solid bodies both systems are supposed to perform opposite oscillations, in liquid bodies, oscillations in the same direction. When solids are being melted, it is the function of the latent heat to change the direction of the oscillation. The author seeks to demonstrate by means of the microscope the molecular motions existing in liquids.

- 265.** 1862. PLATEAU, FELIX. Sur un mode particulier de produire les bulles de savon. *Bull. Acad. Belg.*, (2) Vol. 13, p. 286. See also *Pogg. Ann.*, Vol. 121, p. 653, (1864.)

When throwing a sheet of soap water into the air under an angle of about 45 degrees, it resolved itself into soap bubbles of different sizes, from 8 to 9 centimeters downwards. He presumes that clouds originate on this principle.

- 266.** 1863. MEUNIER. On the globular form that liquids may assume on surfaces of their own kind. *Comptes Rendus*, Vol. 57, p. 401.

It is demonstrated that under certain precautions all liquids, even water can be made to form globules of their own kind on their surfaces.

- 267.** 1863. DUPREZ, F. Note sur la cause qui s'oppose à l'introduction d'un liquide dans un vase à orifice étroit. *Bull. Acad. Belg.*, (2) Vol. 16, p. 11.

A vessel having a very narrow neck or admission tube, cannot well be filled with a liquid, not so much because the air is opposing admission, but on account of the resistance of the capillary surface of the liquid. For the admission tube, a maximum diameter exists below which no fluid can enter the vessel. This diameter closely depends on the cohesion, (capillarity) not the viscosity of the fluid. Thus a very viscous liquid but of small cohesion, like Bitter Almond Oil, may pass a tube, which another much thinner liquid of great cohesion, like Water, cannot pass, because the latter forms a larger surface of capillary equilibrium. Beyond the maximum diameter, the capillary equilibrium of the fluid becomes unstable, and the liquid enters the vessel.

- 268.** 1863. TOMLINSON, CH. *Experimental Essays*. London, 1863.

The following special point may be mentioned here: p. 47, he states that creosote is slightly heavier than water; (sp. g.=1.056;) but by carefully delivering a drop to the surface of water from the end of a glass rod, it will not sink; but the under surface of the drop will be convex below the general surface of the water.

- 269.** 1863. GRAHAM. On the molecular Mobility of Gases. *Phil. Trans.*, (1863) p. 385-405. See also *Ann. Chim. Phys.*, (4) Vol. 2, p. 107-142, (1864.)

Various gases were aspirated through membranes of artificial graphite and other materials into a partial vacuum in which was maintained a constant degree of vacuity. Then it was found that the lighter gas passed through the porous membrane more readily than the heavier gas. The penetration points for several gases were found to be in the ratio of the square roots of their densities. (Compare No. 130.) This behavior of gases suggests to the author the possibility of separating mixtures of gases by aspirating them through porous membranes. (Atmolytic.)

- 270.** 1863. PROCTOR, B. S. Graduated Measures. *Amer. Jour. Pharm.*, Vol. 35, p. 247. From *Chemist and Druggist*, 1863.

Points out some sources of error in reading graduated measures, the chief source being the discrepancy between readings made from the general surface of the fluid or its capillary edge. The former method is preferable.

- 271.** 1863. GOPPELSROEDER. On a new method for determining the Nature of a Mixture of Coloring principles. *Amer. Journ. Pharm.*, Vol. 35, p. 178. See also *Pogg. Ann.*, Vol. 115, p. 487-494, (1862.)

Studies the capillary action of filtering paper on solutions, as observed before by Schoenbein. (See No. 259.) The author discovers the property of Picric Acid to be conspicuous among many solutions in its power to rise in filtering paper. This behavior of Picric Acid permitted the author to establish with certainty its presence in commercial fuchsin obtained from coal tar.

- 272.** 1863. MUSCULUS. Des Phénomènes capillaires appliqués à la détermination de la richesse alcoolique des vins et de la force de l'acide acétique. *Mém. Méd. Milit.*, Vol. X, p. 465-475 and Vol. XIII, p. 74-80. See also *Chem. Centralblatt*, Vol. 9, p. 922-925, (1864.)

The author points out the marked influence which small amounts of Alcohol (one per cent. and less) or Acetic acid have on the capillarity of water, and suggests the use of his capillarimeter, which for example indicates the presence of 1-40 per cent. of alcohol, where the regular methods of analysis fail. Extractive matters, as sugar, salts, have much less influence upon the capillarity of water than Alcohol or Acetic Acid.

- 273.** 1863. WILHELMY, L. Ueber die Abhängigkeit der Capillari-täts-Constanten des Alcohols von Substanz und Gestalt des benetzten festen Körpers. *Pogg. Ann.*, Vol. 119, p. 177-217.

The constant of capillarity herein considered being pronounced to be the weight of liquid which a solid can carry along the unit of length of the latter, the author introduced a novel method for determining this constant, by direct weighing. He observes, however, that the number is not constant but variable, depending both on the nature of the solid, and especially becoming less the more curved the solid is. (See Wertheim, No. 250.) Besides, his results lead him to presume that a condensation of liquid takes place on the surface of the solid. (See Poisson, No. 118.) Subsequent workers have taken issue with these statements.

- 274.** 1863. BERGER. Ueber den Sphäroidalzustand. *Pogg. Ann.*, Vol. 119, p. 594-697.

The main phases of Leidenfrost's Phenomenon (see No. 28.) are critically reviewed and original experiments added.

- 275.** 1864. MENSBRUGGHE, VAN DER. Sur quelques effets curieux des forces moléculaires des liquides. *Bull. Acad. Brux.*, Vol. 18, p. 161-168. See also *Phil. Mag.*, (4) Vol. 18, p. 434-8. *Pogg. Ann.*, Vol. 127, p. 97-105, (1866.)

He describes the formation of liquid bubbles by a certain peculiar manipulation, similar to that recorded by F. Plateau. (See No. 265.) This phenomenon has a bearing on the theory of the formation of fog. Furthermore he describes some capillary experiments with globules of Mercury floating upon water.

- 276.** 1864. GUTHRIE, FRED. On Drops. *Proc. Roy. Soc.*, Vol. XIII, p. 444-483, (1864) and Vol. XIV, p. 22-33, (1865.) See also *Pogg. Ann.*, Vol. 131, p. 128. *Fortschr. d. Physik*, 1865, p. 99, and *Chem. News*, Vol. 10, p. 270.

The author determines the weight of drops of various liquids, (Cocoanut Oil, Salt Solutions, Water, Mercury, etc.) when forming under various conditions, e. g., forming in air, or surrounded by other liquids and mixtures of liquids, and either falling or rising in the latter, according to the specific gravities. The author thinks a chemical diagnosis possible by a closer study of the magnitude of drops and bubbles.

- 277.** 1864. BARBIER, E. Application des phénomènes Capillaires à la construction de divers thermométrographes. *Ann. Chim. Phys.*, (4) Vol. 2, p. 67.

Devises an instrument similar to Rutherford's Thermometrograph, but which allows the reading of both maximum and minimum temperatures by means of two indexes which are being dislocated by the variations in temperature through the capillary action of an air bubble within the instrument.

- 278.** 1864. MAGNUS, G. Ueber die Verdichtung von Dämpfen an der Oberfläche fester Körper. *Pogg. Ann.*, Vol. 121, p. 174-185.

Condensation of Vapors of any kind on the surfaces of solid bodies takes place with such an intensity, that the phenomenon is accompanied by distinct changes in temperature. Hence there exists at any time on the surface of a solid body a stratum of condensed vapors which varies in thickness according to the humidity of the atmosphere.

- 279.** 1864. WILHELMY, L. Ueber die Abhängigkeit des Capillari-täts-Coeffizienten der Flüssigkeiten von ihrer Zusammensetzung. *Pogg. Ann.*, Vol. 121, p. 44-63.

The method of the author to determine the coefficient of capillarity is to weigh the capillary wall which is formed against a solid plate dipped into the fluid. This method is extended to various organic liquids. As a result, certain axioms are pronounced, bearing on the dependency of the coefficient of capillarity on atomic variations.

For example:—Addition of the carbon atom increases, while that of the Hydrogen atom decreases the coefficient of capillarity. The members of an homologous series (whose difference is  $C_n H_{2n}$ ) have about the same Coefficient of Capillarity.

- 280.** 1864. WILHELMY, L. Ueber die Abhängigkeit des Capillari-täts-Coeffizienten der Flüssigkeiten von der chemischen Beschaffenheit und Gestalt der festen Wand. *Pogg. Ann.*, Vol. 122, p. 1-17.

The result of the author's work on Amylalcohol, Glycerin and other organic liquids along the lines pursued in No. 273, is here summarized in several tables, which demonstrate some seemingly regular variations in the coefficients of capillarity for these liquids when in contact with solids of different material and different curvature. Part of these results suggest the theory that a solid when immersed in a fluid, will condense a certain quantity of the fluid on its surface. Glycerin, however, presents a striking exception, if a plate is dipped into it and tared, it becomes lighter upon prolonged standing. The author thinks, that the solid, by surface action, will attract and condense on its surface what little water is contained in the Glycerin.

- 281.** 1864. TATE, T. On the magnitude of a drop of liquid formed under different circumstances. *Phil. Mag.*, (4) Vol. 27, p. 176.

The substance of this paper is expressed in the following abstracts:

1)—Other things being the same, the weight of a drop of liquid is proportional to the diameter of the tube in which it is formed. (This connected with Jurin's Law, (see No. 16.), leads to the following conclusion:)

2)—The weight of the drop is in proportion to the weight of water which would be raised in that tube by capillary action.

3)—The weight of drops of a liquid, other things being the same, is diminished by an augmentation of temperature.

4)—In different solutions of Chlorid of Sodium, or other neutral salts, the increment in the weight of the drops is in proportion to the weight of the dry salt in solution.

- 282.** 1864. TOMLINSON. On a new variety of the Cohesion figures of liquids. (Submersion figures.) *Phil. Mag.*, (4) Vol. 27, p. 426.

Describes and gives illustrations of a new class of figures obtained by placing a drop of a liquid upon the surface of another, in which it sinks to the bottom. A typical example is afforded by a solution of Cochineal dropped into water. In some cases (e. g., Bitter Almond Oil and Benzol) liquid rings are produced, the formation of which he discusses. (Compare No. 256.)



- 283.** 1864. TOMLINSON. Cohesion and Submersion figures. *Phil. Mag.*, (4) Vol. 28, p. 354.

Continues to utilize the phenomena of Cohesion and Submersion figures for the detection of adulterants in oils: e. g., Poppy Oil and Olive Oil. Illustrations of these beautiful phenomena are given. (See No. 282.)

- 284.** 1865. CHEVREUL. Extrait d'un Mémoire sur des phénomènes d'affinités capillaires. *Comptes Rendus*, Vol. 63, p. 61-69. See also *Jahresb. f. Chem.*, 1866, p. 8.

Institutes a series of experiments demonstrating the displacement of oils by water, or water by oils, from their respective intimate contact with certain mineral bodies, as White Lead, Kaolin, etc. This is with a view of applying the results to the arts of painting and varnishing and to agriculture.

- 285.** 1866. MEYER, O. E. Ueber die Strömung von Gasen durch Capillarröhren. *Pogg. Ann.*, Vol. 127, p. 253-281 and p. 353-382.

For the motion of gases through capillary tubes he arrives theoretically at a law exactly corresponding to that of Poiseuille and Hagenbach for the flow of liquids through capillary tubes. (See No. 246.) In order to test the correctness of this law he applies thereto in detail the experimental data recorded by Graham. (See No. 254.)

- 286.** 1866. ECKHARD, C. Der gegenwärtige experimentelle Thatbestand der Lehre von der Hydrodiffusion durch tierische Membranen. *Pogg. Ann.*, Vol. 128, p. 61-100.

The following is an abstract of the author's conclusions:

- 1)—In equal times there is an equal amount of diffusion, (in both directions), i. e., the endosmotic equivalents remain the same.
- 2)—The endosmotic equivalents remain constant at temperatures varying within certain limits.
- 3)—Dried membranes cause a higher endosmotic equivalent than fresh ones, (because the salt current is diminished, while the water current remains unchanged).
- 4)—Velocity of diffusion increases with temperature according to a definite law, which he found empirically.
- 5)—It also increases with concentration; both the salt current and the water current become faster, the water current more so than the salt current, hence their quotient, i. e., the endosmotic equivalent, increases.

- 287.** 1866. ROGER, E. Mémoire sur les phénomènes capillaires. *Comptes Rendus*, Vol. 62, p. 134-138.

The author states that the commonly accepted hypothesis, that in capillary phenomena the action of molecular forces becomes altogether imperceptible at the smallest perceptible distances, is not precisely correct.

He introduces a formula expressing a relation between the height of capillary rise and the diameter of the tubes, containing a correction for the action of the solid upon the fluid at very small, yet perceptible distances. The correctness of his formula he tested by applying thereto the accurate experimental results of Simon de Metz. (See No. 202.)

- 288.** 1866-1868. DUPRE, A. Théorie Mécanique de la Chaleur. *Ann. Chim. Phys.*, (4) Vol. 7, p. 236-282 and p. 406-428. Vol. 9, p. 328-384. Vol. 11, p. 194-220 (1867) and Vol. 14, p. 64-143 (1868.)

The author applies the results of preceding memoirs concerning the gaseous state of matter, latent heat and molecular energy to the study of capillary phenomena upon thermodynamic principles.

In Vol. 7, the force of attraction and separation of surfaces is considered both theoretically and experimentally.

Vol. 9 contains the laws of molecular forces as applied to capillarity proper and the various phenomena connected with it.

Vol. 11 speaks of the influence of temperature and pressure in the capillary phenomena. In this connection it is of interest to note the following fact herein strikingly demonstrated, viz., that the height of the column in a capillary tube will not be sensibly affected by heating the mass of fluid above which it rises, as long as the meniscus itself retains its temperature. If heat is applied to the meniscus direct, the column will sink.

In Vol. 14 interesting relations between molecular attraction and chemical equivalents are established.

- 289.** 1866. DUPRE. *Théorie Mécanique de la Chaleur*. Chap. IX, 206. Capillarité. (See No. 288.)
- 290.** 1866. WATTS. *Dictionary of Chemistry*, Vol. I, London. 1866. "Capillarity." See also Ed. of 1894.
- 291.** 1866. LAMARLE. *Theorie der Stabilität flüssiger Lamellensysteme*. *Pogg. Ann.*, Vol. 128, p. 477. From *Bull. Acad. Belg.*, (2) Vols. 17 and 20.  
Lamarle, by theoretical considerations, establishes the laws according to which liquid films, when attached to wire frames of special shapes, must combine and arrange their edges, if a stable lamellar system is to be produced.
- 292.** 1867. PLATEAU, J. Title as in No. 182. *Pogg. Ann.*, Vol. 130, p. 149-159, 6th series, and p. 264-277, 7th series. From *Mém. Acad. Bruxelles*, Vol. 33.  
A theory is given of fluid Laminar Systems, supported by experiments with wire frames dipped into the film-producing liquid.
- 293.** 1867. DAGUIN. *Traité de Physique*. Third edition, Paris, 1867. Vol. I, p. 209.
- 294.** 1867. VOIT, E. Ueber die Diffusion von Flüssigkeiten. *Pogg. Ann.*, Vol. 130, p. 227 and p. 393.  
Sought to determine the constants of diffusion (see Fick, No. 214,) of Grape Sugar and Cane Sugar solutions, ascertaining the percentage of the diffusing layers at regular intervals of time by means of a Soleil-Dubosque's Saccharimeter sliding vertically. (Compare No. 223.)  
For Cane Sugar he finds the constant to be 0.3144.  
For Grape Sugar . . . . . 0.3180.  
The gradual march of the process of diffusion as observed in these experiments, is illustrated by lucid diagrams.
- 295.** 1867. PLATEAU, F. Umwandlung eines flüssigen Cylinders in gesonderte Kugeln. *Pogg. Ann.*, Vol. 132, p. 654.  
The tendency of a long liquid cylinder of small diameter to contract into a succession of small globules, is here demonstrated by placing a suitable thread of cotton, weighted at one end, vertically into water or olive oil, and then dexterously withdrawing it; the phenomenon succeeds better if the thread is stretched horizontally, dipped into the liquid and withdrawn.
- 296.** 1867. MENSBRUGGHE, G. VAN DER. On the Tension of liquid films. *Phil. Mag.*, (4) Vol. 33, p. 270-282. From *Bull. Acad. Belg.*, (2) Vol. 22. Also *Pogg. Ann.*, Vol. 133, p. 277-292.  
Demonstrates the existence of a contractile force in soap films, employing under certain precautions flexible threads of cotton or light metallic rings. Evolves the laws of equilibrium for the cases mentioned.
- 297.** 1868. MENSBRUGGHE, G. VAN DER. On the tension of liquid films. *Pogg. Ann.*, Vol. 134, p. 455-468, From *Bull. Acad. Belge.*, (2). Vol. 23.  
Theoretical investigations regarding the equilibrium of liquid films. (See No. 296.)

- 298.** 1868. BECQUEREL, M. On the chemical effects produced in capillary spaces. *Phil. Mag.*, (4) Vol. 36, p. 437-445, (1868.) From *Comptes Rendus*, 1867 and 1868.

The following reaction is a type of the phenomena discovered and elaborated upon by the author. A glass tube with a crack of not more than capillary width is filled with a concentrated solution of Nitrate of Copper, and this tube then inserted into a test glass containing a solution of Monosulphid of Sodium of definite strength, the surfaces of the two liquids being brought to the same level. After a short time, a very brilliant deposit of metallic Copper, (not Copper Sulphid as should be expected,) of crystalline texture appears, increasing in thickness, little by little, enlarging the crack, until the tube breaks. Small cylinders of copper, 2 millims. in diameter could be obtained in this manner.

Similar reductions took place with Salts of Silver, Lead, Gold, Tin, Cobalt and Nickel; also when employing capillary spaces of different (and more convenient) forms. These phenomena, according to Becquerel are due to the combined action of affinity, molecular attraction and electricity.

- 299.** 1868. BULIGINSKI, A. Untersuchungen über die Capillarität einiger Salzlösungen bei verschiedener Concentration. *Pogg. Ann.*, Vol. 134, p. 440-454.

The constants of Capillarity were carefully determined for solutions of  $\text{KNO}_3$  and  $\text{NH}_4\text{Cl}$  both of different strengths at three distinctly different temperatures. It was observed that the solutions of Ammonium Chlorid have higher capillarity than water, and increase in capillarity with concentration. (See Valson, No. 311.)

- 300.** 1868. SACHS. *Lehrbuch der Botanik*, Leipzig, 1868. Capillarität, p. 520.

- 301.** 1868. QUINCKE, G. Ueber die Capillaritäts-Constanten fester Körper. *Pogg. Ann.*, Vol. 134, p. 356-367.

The author advocates the existence of a surface tension in solid bodies, especially in substances which have been allowed to cool from the liquid (melted) condition. Examples: Glass, drawn wires, putty. The molecules of such surfaces, not being disturbed while assuming their equilibrium, this explains the excessive hardness of these surfaces. The author determines the constant of Capillarity for several metals from the weight of drops formed upon fusing these metals.

- 302.** 1868. QUINCKE, G. Ueber die Capillar-Constanten geschmolzener Körper. *Pogg. Ann.*, Vol. 135, p. 621-646.

Determines the Constants of Capillarity ("Specific Cohesion") of many fusible substances by weighing the drops which they form upon being heated above their melting points. In this manner he finds remarkable relations. Thus, if the volume of a drop of sulphur is ONE, that of Silver, or Mercury dropping through the same tube is 2, of Gold about 3, of Water, or Borax, or Soda, 4, of Zinc, 6, of Sodium, 12, of Potassium, 20.

- 303.** 1869. ANDREWS, TH. On the continuity of the gaseous and liquids states of matter. *Philos. Trans.*, 1869, p. 159 and 575. Also see *Pogg. Ann.*, Erg. Vol. 5, p. 64. *Phil. Mag.*, (4) Vol. 39, p. 150-153, (1870.)

When Carbonic Acid gas is compressed at temperatures at or below the critical point ( $30.9^\circ \text{C}$ ) a definite degree of pressure will produce liquefaction attended by a sudden and plainly noticeable contraction of volume. But at higher temperatures, say  $48^\circ \text{C}$ , and under the influence of an excessive pressure, no sudden passage from the gaseous into the liquid condition is observed. This transformation is effected by a series of gentle gradations. Hence the author concludes that the gaseous and the liquid states are only but widely separated forms of the same condition of matter.



- 304.** 1869. QUINCKE, G. Ueber die Capillar-Constanten geschmolzener chemischer Verbindungen. *Pogg. Ann.*, Vol. 138, p. 141-155.

Determines the "specific cohesion" of various salts, metals and organic substances, etc., by a new method, viz., measuring certain dimensions of drops formed by fusing these substances, and calculating the specific cohesion according to a simple algebraical relation. He finds the law confirmed according to which the specific cohesion of a number of substances present striking regularities. (See No. 802.)

- 305.** 1869. BEER, AUG. *Einleitung in die mathematische Theorie der Elasticitet und Capillaritet, Leipzig, 1869.*

- 306.** 1869. LUEDTGE, R. Ueber die Ausbreitung von Flussigkeiten auf einander. *Pogg. Ann.*, Vol. 137, p. 362.

Studying the expansion of liquids upon liquids, he finds that upon arranging them according to their constants of capillarity, beginning with the smallest number, each liquid of the series will spread upon any one following, e. g., Alcohol will spread on Poppy Oil, the latter on water, etc. An exception occurs with regard to Mercury and water, as the latter seemingly does not spread on the former. QUINCKE however, has later succeeded in producing this phenomenon. (See No. 312.)

- 307.** 1869. QUINCKE, G. Ueber die Entfernung, in welcher die Molecularkrefte der Capillaritat noch wirksam sind. *Pogg. Ann.*, Vol. 137, p. 402.

He determines the distance of molecular action by the following method: Upon a clean glass plate is deposited a thin sheet of silver in wedge shape, leaving part of the glass uncovered. When the plate thus prepared is dipped into water, the glass is wetted, the silver part is not wetted. Adjoining the free glass part there is a silver zone where the boundary line presents an intermediate condition, owing to the molecular action of the underlying glass upon the water. Hence the spot at which the boundary line becomes uniformly convex, also indicates the limit of the sphere of action of the glass molecules. It only remains to measure the thickness of the film at that particular spot to obtain the radius of molecular action. For glass, silver and water, for example, it was found to be greater than 0.0000542 mm. (See Plateau, No. 261.)

- 308.** 1869. VALSON, ALPH. Sur les actions moleculaires dans le chlore, le brome et l'iode. *Comptes Rendus*, Vol. 69, p. 1140. See also *Jahresber. f. Chem.*, 1869

He sought to establish a capillary relation between the elements Chlorin, Bromin and Iodin, by dissolving molecular quantities of the respective Potassium Salts in the same volume of water, and observing the height of rise of the solution in a capillary tube of 1 mm. diameter. The values thus obtained together with the results of additional experiments on the three corresponding Cadmium salts, exhibit a regularity similar to that existing among the atomic weights, and other physical properties of the three Halogens.

- 309.** 1870. DUCLAUX, E. Sur la tension superficielle des liquides. *Ann. Chim. Phys.*, (4) Vol. 21, p. 378-435.

Gives an historical development of the notion of surface tension of liquids, making on this basis a special study of Drops with practical applications (Drop Alcoholometer), and of the stability of Emulsions. In the latter respect, he concludes that the emulsions formed by the mixture of two liquids are the more stable, the nearer the surface tension of the constituents, the nearer their densities and the greater their viscosity. (Compare No. 821.)

- 310.** 1870. MENSBRUGGHE, G. VAN DER. Sur la tension superficielle des liquides considérée au point de vue de certains mouvements observés à leur surface. *Ann. Chim. Phys.*, (4) Vol. 20, p. 121-135.

Like Segner and Thomas Young, the author advocates the existence of a surface tension in fluids, having an equal magnitude in all points of the surface at the same temperature. If this tension is affected at any one point by an outside influence, e. g., the approach of a more or less volatile substance of different surface tension, a motion is necessarily produced upon the surface of the fluid; centrifugal, when the approaching body has a smaller, centripetal, when it has a greater surface tension. Numerous illustrative examples are given.

- 311.** 1870. VALSON, ALPH. Etude de l'action moléculaire fondée sur la théorie de l'action capillaire. *Ann. Chim. Phys.*, (4) Vol. 20, p. 361.

Studying the capillary behavior of salt solutions, the author found the following interesting laws of "Capillary moduli": He prepared Normal saline solutions containing one gramme-equivalent of salt in one liter of water, and determined the capillary rise in the same tube, using two series of Normal solutions having two fixed metals or metallic radicals as their basis, (say Ammonium and Cadmium,) and varying acid radicals combined with these metals. He found for example, that the difference in the capillary rise of the Chlorids is the same as that of the Bromids or the Sulfates. In this case if the rise of the  $\text{NH}_4$  salt assumed to be  $=0$ , the constant (or modulus) for Cd=4.3. The author gives a table assigning to each metal its capillary modulus.

A similar table of constants is obtained when reversedly two acid radicals are taken as the basis, and the metals vary. Solutions of Ammonium chlorid and Lithium chlorid possess a higher capillarity than even water, (see No. 299,) and, by a remarkable coincidence, these two substances are also distinguished by possessing a higher index of refraction than water.

- 312.** 1870. QUINCKE, G. Ueber die Capillaritäts-Erscheinungen an der gemeinschaftlichen Oberfläche von Flüssigkeiten. *Pogg. Ann.*, Vol. 139, p. 1-81.

He is the first to obtain numerical values for the Constants of Capillarity at the zone of contact of two immiscible liquids. Makes use of his new method of determining these constants, (see No. 304,) which consists in measuring certain dimensions of flat drops of the liquid, reposing either in air or another liquid. The constant of Capillarity (by him called specific cohesion) is a function of these dimensions. The results of these extensive investigations, covering all the important phases of Capillarity, are finally summarized.

- 313.** 1870. STAHL, M. Ueber einige Punkte in der Theorie der Capillaritäts Erscheinungen. *Pogg. Ann.*, Vol. 139, p. 239.

Theoretical considerations, intended to vindicate Laplace's theory. (See No. 64.)

- 314.** 1870. DUBOIS-REYMOND P. Ueber den Einfluss der Capillarität auf die Erscheinung der Ausbreitung der Flüssigkeiten. *Pogg. Ann.*, Vol. 139, p. 262-275.

If a drop of a fluid is placed upon the surface of another fluid, it will expand or not according to the magnitude of the edge angle of the drop. This angle is a function of the surface tensions at the common surface of the two fluids and air, as expressed in NEUMANN'S THEOREM, (which is explicitly detailed in the paper.) He then seeks to give explanation of the swift currents of a fluid caused by vapors approached, antagonizing the view of Mensbrugghe on this point. (See No. 310.)

- 315.** 1870. LUEDTGE. Ueber die Spannung flüssiger Lamellen. *Pogg. Ann.*, Vol. 139, p. 620.

Regarding the tension of liquid lamels he arrives at the following conclusion: 1) Liquid films immediately after their formation acquire a thickness less than the double radius of the molecular sphere of action; hence the cohesion of a film is not constant but a function of its thickness. 2) The tension of a liquid film increases when thickness decreases. (See however No. 223.)

- 316.** 1870. **WARBURG.** Ausfluss von Quecksilber aus gläsernen Capillarröhren. *Pogg. Ann.*, Vol. 140, p. 369.

Contrary to Poiseuille's results which the latter obtained for Mercury, (see No. 162.) Warburg found that the quantity of Mercury flowing through a capillary glass tube is in proportion to the 4th, not the 3rd power of the radius of the tube.

- 317.** 1870. **BOLTZMANN, L.** Ableitung der Grundgleichungen der Capillarität aus dem Prinzip der virtuellen Geschwindigkeiten. *Pogg. Ann.*, Vol. 141, p. 582-590.

Purely theoretical considerations. (Compare Gauss, No. 115.)

- 318.** 1870, **MENDELEEFF, D.** Bemerkungen über die Untersuchungen von Andrews über die Compressibilität der Kohlensäure. *Pogg. Ann.*, Vol. 141, p. 618.

Mendeleeff denies the existence of an intermediate state between liquid and gas, as advocated by Andrews, in certain phases of the latter's experiments. (See No. 303.) Adduces in support the experiments of Cagnard de la Tour and Wolf. (See No. 218.)

He accepts two kinds of limitations of the compressibility of gases. At low temperatures they yield a liquid, and at high temperatures they reach a limit of gaseous volume which merely coincides with the limit of compressibility of fluids.

- 319.** 1870. **THOMPSON, SIR W.** Effect of the curvature of the surface of a liquid on the thermal equilibrium between the liquid and the vapor in contact with it. *Proc. Roy. Soc. Edinb.*, 1870, February 7th. Also see *Phil. Mag.*, (4) Vol. 42, p. 448, (1871.)

A fluid at a higher level has less vapor pressure than it has at a lower level, hence differences in curvature of liquids involve differences of vapor pressure.

If two separate portions of a liquid are placed at different levels, the difference of vapor pressure would, under ideal conditions, exert an equalizing influence by causing the fluid to evaporate from the higher level and condense into the lower.

If a capillary tube closed at the lower end and containing some water, be inserted in a larger mass of water within a vessel hermetically closed, the difference of vapor pressure outside and inside of the capillary tube will tend to restore the equilibrium, which takes place only when the fluid in the capillary tube occupies the height which it would reach by capillary-hydrostatic action, if the lower end was open. If below that height, water would condense into the tube, if above, it would evaporate from the tube.

The author evolves two formulæ expressing the exact relation between the vapor pressure and curvature of a liquid on one hand, and the differences of vapor pressure and differences of level on the other.

- 320.** 1870. **WUELLNER, Ad.** *Experimentalphysik.* Leipzig, 1870. 3rd Ed., Vol. I, Capillarität, p. 245-278.

- 321.** 1870. **PLATEAU, J. J.** Neues Princip betreffend die Spannung von Flüssigkeitsoberflächen. *Pogg. Ann.*, Vol. 141, p. 45.

The forces which cause liquids to foam are not so much cohesion or viscosity of the fluid, but rather their *surface viscosity* in relation to surface tension. The existence of this force is herein clearly and ingeniously established by the author, by means of a magnetic needle which was made to rotate within the surfaces of a series of fluids successively. With water and saponine solution the surface viscosity is greater, with alcohol, the surface viscosity is smaller than the inner viscosity. When the quotient between surface viscosity and surface tension is great, we have liquids producing stable foam, (Saponine—and Soap solution.) When the quotient is small, as with water, there is no or very little tendency to foam.

- 322.** 1870. **MENSBRUGGHE, VAN DER.** Oberflächliche Zähigkeit der Lamellen aus Saponinlösung. *Pogg. Ann.*, Vol. 141, p. 297.

Gives experimental support to M. Plateau's discovery of the great surface viscosity of Saponine solution. (See No. 231.) The author, with the aid of an Electrophor, succeeds in obtaining open films of such a solution which have quite the appearance of solid films like mica, and are also very flexible. Some fragments being collected on a cloth, at once coalesce and form drops.



- 323.** 1870. MENSBRUGGHE, VAN DER. Ueber einen durch Herrn Lüttge angegebenen molecular-statischen Satz. *Pogg. Ann.* Vol. 141, p. 608.

If two liquid films of the same fluid material are made to close both ends of a hollow cylinder, the author demonstrates by accurate measurements that the curvature and hence the tension of the two films remains constant, even if one of these films has become so thin as to show colors. Luedtge had asserted that in the latter case the curvature is less, i. e., the tension increased. (See No. 315.)

- 324.** 1871. BUDDE, E. Ein neues Experiment, und einige Bemerkungen zur Theorie des Leidenfrost'schen Phänomens. *Pogg. Ann.*, Vol. 142, p. 158.

The author succeeds in producing Leidenfrost's phenomenon very readily with water at temperatures below  $100^{\circ}\text{C}$ . by carefully excluding the air. This sustains the proposition that the force necessary to support the drop, is equal to the weight of the drop plus the atmospheric pressure which is to be overcome.

The author finally points out in what manner the form of the dish influences the shape of the drop in its motions.

- 325.** 1871. MOUSSON, ALB. Bemerkungen über die Theorie der Capillarerscheinungen. *Pogg. Ann.*, Vol. 142, p. 405-417.

Gives a succinct outline of the probable constitution of matter and the forces which underlie capillary action, especially emphasizing the change in homogeneity of liquids at their free surfaces, or at the surface of their contact with solids. This view was held before by Poisson (see No. 118.) and Wilhelmy. (See No. 280.) The author then proceeds to evolve the three main laws of capillarity upon the principle of the conservation of molecular energy.

- 326.** 1871. MARANGONI. Ueber die Ausbreitung der Tropfen einer Flüssigkeit auf der Oberfläche einer anderen. *Pogg. Ann.*, Vol. 143, p. 337-354.

The author concludes that a drop of a fluid will expand on the surface of another liquid, if the surface tension of the latter is greater than the sum of the surface tensions of the lower and upper surfaces of the drop. If it is smaller, the drop retains lens shape. He further insists that the phenomena of expansion of drops can best be studied when carried out on a large scale, and describes the color phenomena which he systematically observed in experiments carried out on the large basin in the Tuileries of Paris.

- 327.** 1872. MENSBRUGGHE, VAN DER and TOMLINSON, CH. On a relation between the surface tension of liquids and the Supersaturation of Saline Solutions. *Proc. Roy. Soc.*, Vol. 20, p. 342-51. See also *Phil. Mag.*, (4) Vol. 44, p. 223-32.

The authors demonstrate that the state of supersaturation of a salt solution (Glauber's Salt in Water) is broken, and the salt at once crystallizes, when the surface tension of the solution is diminished by the latter coming into contact with substances of a considerably lower surface tension, like drops of Ether, Alcohol and certain Oils. The local application of heat at parts of the surface however, does not seem to diminish the surface tension sufficiently to cause the salt to crystallize.

- 328.** 1872. DUCLAUX, E. Recherches sur les lois des mouvement des liquides dans des espaces capillaires. *Ann. Chim. Phys.*, (4) Vol. 25, p. 433-501.

The author makes an extensive, partly experimental study of the flow of liquids through capillary tubes, progressing to annular capillary channels of known dimensions, to porous diaphragms, and finally to animal membranes, in the latter case utilizing the results of Schmidt (see No. 220.) and Liebig. (See No. 181.)

The author concludes that the same relations that exist for capillary tubes between the quantity of outflow, pressure, and width and length of the tubes (Poiseuille's law, see No. 162.) holds good also in the more complicated cases, as far as can be ascertained.

Further paragraphs are devoted to phenomena of molecular adhesion, comprising phenomena of surface absorption, the separating action of paper and other important subjects.

- 329.** 1872. DUPRÉ, A. On the specific heat and other physical characters of mixtures of Methylic Alcohol and Water. *Phil. Trans.* 1872, p. 331-351.

In Section IV of this memoir, the capillary rise of mixtures of methyl alcohol and water is measured. The results are tabulated and also graphically represented in a curve.

- 330.** 1872. DECHARME, C. Du mouvement ascensionnel spontané des liquides dans les tubes capillaires. *Ann. Chim. Phys.*, (4) Vol. 27, p. 228-242.

Studying the velocity of spontaneous rise of liquids in both vertical and in inclined capillary tubes, the author finds that each liquid possesses a "capillary velocity" of its own which is the velocity of rise observed in tubes of 1 mm. diameter, and at a definite temperature, e.g., 0° C. Diagrams of curves are added which illustrate at a glance the capillary velocities of different liquids. The capillary velocities in the spontaneous ascent of liquids bear no analogy to the velocities of outflow, where pressure is employed. (Poiseuille's experiments, see No. 162.) In the latter case salts tend to accelerate the velocity of water, while with the exception of Ammonium Chloride (see No. 311.) the reverse condition takes place in the spontaneous ascent of liquids in capillary tubes.

- 331.** 1872. MENSBRUGGHE, VAN DER. Ueber eine merkwürdige Thatsache beim Kontakt gewisser Flüssigkeiten mit sehr verschiedenen Oberflächen-Spannungen. *Pogg. Ann.*, Vol. 146, p. 623. From *Bull. Acad. Belg.*, Vol. 33. Also see *Ann. Chim. Phys.* (4) Vol. 26, p. 318-321.

Whenever a fluid of great surface tension, e. g., Water, holding gases in solution, comes into contact with a liquid of low surface tension, e. g., Alcohol, Ether, Oil of Turpentine, etc., an evolution of the gas dissolved becomes more or less apparent, (see No. 143.) The phenomena of cohesion figures (see No. 283,) are to be explained on the same principle.

- 332.** 1872. BERGER. Leidenfrost's Phenomenon. *Pogg. Ann.*, Vol. 147, p. 472 and 474.

Criticism of articles on this subject by E. BUDDE (see No. 324,) and R. COLLEY. (*Pogg. Ann.*, Vol. 143, p. 125.)

- 333.** 1872. BECQUEREL. Mémoire sur l'emploi des forces électrochimiques et électrocapillaires pour la formation, en proportions définies, des amalgames, et de plusieurs composés cristallisés. *Comptes Rendus*, Vol. 75, p. 1729-1733.

Continuing his former researches on chemical effects produced in capillary spaces (a fissured glass tube,) (see Nos. 99 and 298,) the author describes the mode of producing amalgams of silver and copper, and other crystallizable compounds.

- 333a.** 1872. MAXWELL, J. CLERK. *Theory of Heat*. New York, 1872. Chapter XX, p. 260-274, treats of Capillarity.

- 334.** 1872. GUEROUT, AUG. Sur les dimensions des intervalles poreux des membranes. *Comptes Rendus*, Vol. 75, p. 1809.

The pores of a membrane being likened to short capillary tubes perpendicular to its faces, the law of Poiseuille (see No. 162,) is thereto applied and a formula obtained, by means of which the dimensions of the pores may be calculated from given quantities experimentally to be established. Values are obtained for bladder, gold beater's skin and parchment paper. Actual measurements on fine Asbestos showed the capillary cross section to vary from 16 to 33 ten thousandth of a square millimeter, average: 24 mm. square. Calculation by the formula: 25 ten thousandth of a mm. square, hence a close coincidence.

- 335.** 1873. QUINCKE G. Sur les couches liquides à la surface des corps solides. *Ann. Chim. Phys.*, (4) Vol. 28, p. 286-288.

The diminution of the quantity of water passing through a porous diaphragm in the unit of time while the pressure remains the same, was explained by the author in 1859, by the assumption that particles of tile are mechanically carried off and obstruct the passage. Duclaux (see No. 328,) ascribed the phenomenon to the thickening of a supposed liquid layer adhering to the pore-walls. Quincke now upholds his view, while not denying the simultaneous existence of a liquid layer less mobile, as pointed out by Bède, (see No. 248,) Wilhelmy (see No. 273,) and others. Quincke also recalls his former observation (1860,) that a mixture of alcohol and water pressed through porous tile moistened with water, comes through with a less spec. grav. than the entering fluid.

- 336.** 1873. MEYER, O. E. Die Gültigkeit des Poiseuille'schen Gesetzes für die Transpiration der Gase. *Pogg. Ann.*, Vol. 448, p. 1-44.

The author's results demonstrate that Poiseuille's law for the flow of liquids through capillary tubes (see No. 162,) holds also good with great exactness for the transpiration of gases through capillary tubes.

- 337.** 1873. PLATEAU, J. J. *Statique expérimentale et théorique des liquides.* 2 Vols. Paris, London, Gand and Leipzig. 1873,

"This work consists essentially of the collected series of papers *"On the figures of Equilibrium of a Liquid Mass without Weight,"* (see Nos. 154 and 292,) which the distinguished physicist of Ghent has published during the years 1843-1868, with numerous additions relating chiefly to the work of other investigators in the same field of research. The present book derives a special value and beauty from the sagacity with which the author has followed out the physical and mathematical consequences involved in the Principle of the equality in all directions of the Tension of a Liquid Surface. . . ." *Phil. Mag.*, (4) Vol. 48, p. 140-141. [1874.]

- 338.** 1873. SCHOLZ, R. Synaphie einiger noch nicht untersuchter Stoffe, insbesondere der zusammengesetzten Aetherarten. *Pogg. Ann.*, Vol. 148 p. 62-76.

Determined the capillarity of compound ethers and other liquids, making measurements both with capillary tubes and adhesion plates of various material. In the latter case he determined the force necessary to detach the disks from the liquids to be examined. (see No. 388.) Both methods lead him to establish the fact that Sulfuric Ether possesses the smallest capillarity, (Synaphy) of all fluids known, next in rank being the compound ethers.

- 339.** 1873. BOUSSINGAULT, JOSEPH. Sur la rupture de la Pellicule des fruits exposés à une pluie continue.—Endosmose des feuilles et des racines. *Ann. Chim. Phys.* (4) Vol. 29, p. 360-367.

Fruits, leaves and roots of plants when immersed in water for definite lengths of time, behave differently as regards the exosmose of sugar. With cherries, raisins, etc. there is exosmose of sugar and endosmose of water which causes the pellicle to burst, showing the effect of rain upon such fruits. With leaves the exosmose of sugar is much slower than with fruits. With roots and germinating rootlets of cereals, the phenomenon does not take place at all. A beet weighing 1075 gms., and containing 100 gms. of sugar, did not show the least trace of sugar in the water after a period of ten days' immersion.

- 340.** 1873. GERNEZ, D. Note relative à l'action prétendue des liquides à faible tension superficielles sur les gaz dissous dans les liquides à forte tension superficielle. *Comptes Rendus*, Vol. 76, p. 89-92.

Adduces experiments to disprove Mensbrugghe's theory regarding the disengagement of gas dissolved in a liquid, and to prove that this is simply due to evolution of air that was absorbed upon shaking. The author also shows that upon placing a saturated aqueous solution of carbonic acid gas upon carbon disulfide, etc., no disengagement of gas will take place, provided that dust or other solid particles are absolutely excluded. The layer of air supposed to be condensed upon their surface, would give rise to the evolution of the gas dissolved. (see No. 331.)



- 341.** 1873. ROGER, E. Théorie des phénomènes capillaires. Fourth memoir. *Comptes Rendus*, Vol. 76, p. 816-819.

Simon de Metz (see No. 202,) had observed that for diameters of tubes below 0.008 mm. the capillary rise seemed to be much higher than simply in inverse proportion to the diameter of the tube, (see No. 18.) The present author through mathematical reasonings arrives at a formula which takes into account this increase of capillary rise. The experimental results of Simon are in good accord with those calculated from the formula.

- 342.** 1873. M. BECQUEREL. Mémoire sur les actions produites par l'attraction moléculaire dans les espaces capillaires. *Comptes Rendus*, Vol. 76, p. 1034-1041.

If two salt solutions capable of forming an insoluble precipitate, e. g., Potassium Sulfate and Barium Chloride are placed in glass vessels and are connected by a fissure having a width of less than several thousandth of a millimeter, the chemical reaction induced by the capillary space takes place so slowly that the product is formed in a crystalline condition. Thus crystallized Lead Chromate and Barium Sulfate were obtained. Such solutions may be in contact with each other within an extremely narrow fissure, without reacting upon each other. In wider fissures, one of the fluids passes and slowly causes a precipitate which creeps along the wall of the cracked tube.

- 343.** 1873. LIPPMANN, G. Relation between Capillary and Electrical Phenomena. *Pogg. Ann.*, Vol. 149, p. 546, (1873.) See also *Comptes Rendus*, Vol. 76, p. 1407, or *Philos. Mag.*, (4) Vol. 47, p. 281-291, (1874.) and *Ann. Chim. Phys.*, (5) Vol. 5, p. 494, (1875.)

These interesting papers demonstrate the cause of the frequently observed inconstancy in the Constant of Capillarity for mercury, which was ascribed by Quincke (see No. 234,) to impurities of the surface. *First law:* The capillary constant at the common surface of Mercury and dilute Sulfuric acid is a function of the electric difference (electromotive force of Polarization,) existing on this surface. The meniscus of a mercurial column in contact with dilute sulfuric acid in a capillary tube will rigidly occupy the same position, if the same electrical difference is maintained in the apparatus by establishing an electric circuit. If the weakest electric current is introduced, the meniscus will occupy another fixed position corresponding to the new electromotive force. On this principle an exceedingly sensitive capillary electrometer was constructed to measure weak electromotive forces, a compensating manometric pressure being used to bring the meniscus back to its zero point.

The capillary constant increases with the electric difference introduced, reaching a maximum at  $e=0.9$  Daniell, then decreases until 2 Daniell is reached.

*Second law:* A mechanical enlargement of the mercurial area in contact with dilute sulfuric acid (e. g., the mere inclination of the vessel containing both, or dropping Mercury through a funnel into dilute sulfuric acid,) gives rise to an increase of electric difference, (indicated by an inserted galvanometer,) hence an increase of surface tension (constant of capillarity,) subject to the maximum before mentioned.

On this principle, an Electrocapillary Motor is constructed, converting either mechanical work into electricity by the aid of capillarity or reversedly the electric current of a cell into mechanical work by the aid of the same class of phenomena.

- 344.** 1873. HUEBENER, TH. Untersuchung über die Transpiration von Salzlösungen. *Pogg. Ann.*, Vol. 150, p. 249-259.

The author measured the time required by equal volumes of salt solutions of related Substances and having the same specific gravity, to pass through one and the same capillary tube. For solutions of NaCl and KCl of equal specific gravity, the velocities of outflow were in inverse ratio to the equivalent weights of these salts, with the chlorides of the alkaline earths, the approximation was not so perfect.

- 345.** 1873. DECHARME, C. Effets frigorifiques produits par la capillarité jointe à l'évaporation. *Comptes Rendus*, Vol. 77, p. 998 and 1157.

Treats of the formation of cauliflower-like crystals of water derived from the moisture of the air, which are formed when a porous substance as e. g., filtering paper dips into a layer of carbon disulfide.

- 346.** 1873. DECHARME, C. Du mouvement ascendant spontané des liquides dans des espaces très étroits, (bandelettes de papier spongieux,) comparé au mouvement ascendant des mêmes liquides dans les tubes capillaires. *Ann. Chim. Phys.*, (4) Vol. 29, p. 415-425.

The author extended his former studies (see No. 330.) comparing the *velocity* with which different liquids rise in capillary tubes and in strips of filtering paper. Both media show analogies as well as differences. Each liquid has its own peculiar *capillary velocity* as well as its own capillary height of rise. A liquid that finally rises highest, has not necessarily the greatest capillary velocity. Curves are plotted to illustrate the various velocities. With capillary tubes, only an aqueous solution of sal ammoniac has a greater capillary velocity than water; with filtering paper, however, 40 liquids out of 207 have a greater velocity and finally rise higher than water, e. g.,  $\text{HCl}$ ,  $\text{HNO}_3$ ,  $\text{Ca Cl}_2$  etc. Moist condition of the surrounding air markedly favors the rise of fluids in bibulous paper.

- 347.** 1873. DECHARME, C. Du mouvement descendant des liquides, comparé à leur mouvement ascendant spontané dans les tubes capillaires. *Ann. Chim. Phys.*, (4) Vol. 29, p. 564-569.

Raise the liquid by suction to double the height to which it would rise spontaneously by capillarity; then release and notice *Velocity of Descent*. The duration of the descending movement, for a great number of liquids is greater than the ascending movement with which it corresponds.

- 348.** 1874. GUEROUT, AUG. Recherches sur l'écoulement des liquides dans les tubes capillaires. *Comptes Rendus*, Vol. 78, p. 351.

Verifies Poiseuille's law (see No. 162.) for the special case of the flow of water through vertical capillary tubes, the lower end of which dips into the lower water surface, when the ratio between charge and length of tube is constant. Another series of experiments developed the remarkable phenomenon that the mean velocity of outflow (i. e. quantity of outflow divided by cross section of the tube,) increased when to the lower orifice ivory disks with circular holes of known and successively decreasing diameter were adapted. Thus the liquid may be supposed to move in concentric cylinders animated with increasing velocity towards the center. Another theory admissible is based on certain observations by Tresca.

- 349.** 1874. ONIMUS, M. De l'influence des substances albuminoïdes sur les phénomènes électrocapillaires. *Comptes Rendus*, Vol. 78, p. 643.

The interposition of a capillary space between two fluids capable of reacting with each other, produces an electrocapillary phenomenon, and the interposition of albumen may be expected to have the same effect. Solutions of Copper sulfate and Potassium oxalate separated in a U tube by a layer of albumen, formed crystals of the double oxalate of Copper and Potassium.

- 350.** 1874. BECQUEREL. On Chemical Actions in Capillary Spaces. *Jour. Chem. Soc. Abst.* 1874, p. 1126, from *Comptes Rendus*, Vol. 79, p. 82-87.

In the reduction phenomena with fissured tubes, (see No. 333.) the chemical action is due to a strong electromotoric force developed. When this force is weaker, as e. g., with parchment paper, or dried collodion, only oxides and related products are formed.

In this manner were obtained  $\text{Cu}(\text{OH})_2$  in blue crystals from Sodium aluminate and Copper nitrate, and crystallized alumina from Potassium aluminate and aluminum chloride, the latter solution being placed into the parchmentized tube. The author discusses the probable bearing of these phenomena upon processes in nature.

- 351.** 1874. GUEROUT, AUG. Influence de la température sur le coefficient d'écoulement capillaire des liquides. *Comptes Rendus*, Vol. 79, p. 1201.

The coefficient of capillary effusion being here defined as the quantity of a fluid passing in one second through one and the same capillary tube and expressed in mm. cubes, this quantity is constant for one and the same liquid at one and the same temperature, and indicates for varying liquids their degree of mobility.

For water and certain salt solutions the increase in capillary mobility with the temperature (from 10° to 20° C.) is represented by a straight line. An elevation of 10° C. increases the mobility of water by one third.

- 352.** 1874. OBERMAYER, A. v. Ueber Ausbreitungserscheinungen einiger Lösungen von Anilinfarben auf Wasser. *Pogg. Ann.*, Vol. 151, p. 130.

Observes in the expansion of solutions of aniline colors upon the surface of water a confirmation of Van der Mensbrugghe's theory, (see No. 331.) that motion is caused by the diminution of the surface tension of water in contact with a liquid of less surface tension.

- 353.** 1874. SIEMENS, W. v. Capillar Galvanoskop. *Pogg. Ann.*, Vol. 151, p. 639.

Is a modification of Lippmann's Capillary Electrometer, (see No. 343.) with a view to employ it in the measurement of resistances of submarine cables on board of ships where the unsteady oscillations preclude the use of Lippmann's Apparatus.

- 354.** 1874. BAUMGARTNER, G. Ueber den Einfluss der Temperatur auf die Ausflussgeschwindigkeit von Wasser aus Röhren. *Pogg. Ann.*, Vol. 153, p. 44-52.

The quantities of flow of water through tubes of varying lengths and diameters (not capillary) were determined. With some tubes, a maximum of outflow was reached for definite temperature which decreased upon further increase of temperature. In some instances a double maximum seems to occur.

Hence, wider tubes than capillary obey the same exceptions as do capillary for tubes below a certain length, (see No. 162.) The longer the tube, the higher the maximum of outflow.

- 355.** 1874. QUINCKE, G. Ueber die angeblichen Beziehungen zwischen den capillaren und electrischen Erscheinungen. *Pogg. Ann.*, Vol. 53, p. 184.

Contrary to Lippmann's experience, (see No. 343.) the author can perceive no connection between the constant of capillarity at the common surface of Mercury and a surrounding fluid, and the electromotive force there originating. The surface tension at the common surface of mercury with liquids conducting electricity is changeable by electrolysis, and may decrease or increase with direction and duration of electric current.

It is not permissible to measure electromotive forces by the magnitude of this surface tension, since accidental and unavoidable impurities materially modify the surface tension of Mercury and other fluids.

- 356.** 1874. MEYER, OSKAR EMIL. Hydraulische Untersuchungen. *Pogg. Ann.*, Jubelband, p. 1-10.

Some important literature on the flow of water through tubes is pointed out, (G. Hagen, 1854 and 1869, G. G. Stokes, *Phil. Trans.* 1847, etc.) The author had an unusual opportunity to study the flow of water through a lead pipe of 3000m. length and 7mm. diameter. One of the interesting results is that pressure (a sudden shock,) exerted at one end of the column, is transmitted through water with a velocity of about 1000 meters per second, which approximates the velocity of sound in water, which is 1400 meters.



- 357.** 1874. MEYER, OSKAR EMIL. Bemerkungen zu der Abhandlung des Herrn Dr. G. Baumgartner, (see No. 354.) *Pogg. Ann.*, Vol. 153, p. 619-621.

The author points out that Baumgartner's results on the influence of temperature upon the velocity of the flow of water through tubes had been anticipated exhaustively by Hagen in 1869, and also by the author himself, (see Nos. 356 and 285.) He found the general law of outflow for wide and narrow, long and short tubes. In the special case of long and narrow tubes, Poiseuille's law (see No. 162,) for short and wide tubes Torricelli's Theorem becomes apparent. A formula expressing this general law, was established and Baumgartner's observations, (see No. 354,) are now utilized to corroborate the correctness of the formula.

- 358.** 1874. LASSWITZ, K. Ueber Tropfen an festen Körpern, insbesondere an Cylindern. *Pogg. Ann.*, Erg. Bd. 6, p. 441-447.

Evolves mathematical expressions for the dimensions of drops generated in contact with solids of various shapes. From the formulae a number of interesting laws are deducible bearing on the geometrical properties of drops.

- 359.** 1874. STEFAN, J. Experiments on Apparent Adhesion. *Phil. Mag.*, (4) Vol. 47, p. 465-466. From *K. Acad. Wiss. Wien.*, 1874.

The phenomenon of separating two plates adhering to each other is not a statical, but a dynamical problem; the smallest force effects a separation; only the time in which a measurable distance is reached becomes the greater, the smaller the force. By theoretical considerations an equation is established which expresses all the experimental laws here arrived at.

- 360.** 1874. DECHARME, C. Du mouvement ascendant spontané des liquides dans les tubes capillaires. *Ann. Chim. Phys.*, (5) Vol. 1, p. 145-208 and p. 318-342.

Increase of temperature diminishes the total height of capillary rise of liquids, but increases their capillary velocity. (see No. 330.) Ammonium chloride and Lithium chloride are the only substances whose aqueous solutions rise higher by capillarity than water. The paper also deals with the capillary rise in inclined tubes, and the second part treats this whole class of phenomena mathematically.

- 361.** 1874. MARIGNAC, C. Recherches sur la Diffusion simultanée de quelques sels. *Ann. Chim. Phys.*, (5) Vol. 2, p. 546-581.

Graham's method (see No. 198,) was employed to study the diffusibility of mixed salt solutions, especially of salts not reacting with each other to form double salts. A simple relation between the diffusibility of the mixture and that of its constituents was not observable. Mixture of two salts in all cases seemed to diminish the diffusibility of the less diffusible. The same value of simultaneous diffusibility was obtained, whether the mixture was one of equal proportions or of equivalent quantities.

- 362.** 1874. DECHARME, C. Du mouvement ascendant des liquides dans les corps poreux. *Ann. Chim. Phys.*, (5) Vol. 3, p. 417-421.

Records the time of rise and the height of rise of water in a variety of organic tissues and inorganic substances. A diagram of curves illustrates the results at a glance.

Water, while surpassed in capillary rise in filtering paper by many solutions (see No. 346,) reasserts itself in more densely porous substances.

- 363.** 1875. EXNER, FRANZ. Ueber den Durchgang der Gase durch Flüssigkeitslamellen. *Pogg. Ann.*, Vol. 155, pp. 321-337 and pp. 443-464.

The diffusion of gases through liquid films, as studied before by Draper (see No. 136, and Marianini, obeys a law different from that for diffusion of gases through porous solid bodies, where the density of the gas is the sole determining factor, (see No. 130.) With liquid films, the absorbability of the gas by the liquid evidently exerts a powerful additional influence. The author's method was to observe the diffusion of one gas into another through a movable soap film that bounded one of the gases contained in a glass tube open at one end. A constant pressure was thus maintained. The ratio of volumes before and after diffusion determined the diffusibility of one gas into the other. In cases where too rapid diffusion tended to destroy the film, the measuring of the diameter of gas bubbles before and after diffusion had to be resorted to. With air and illuminating gas the ratio of diffusion was 2.27, but with air and ammonia this ratio was more than 46,000. The author concludes that the ratio depends on the combined influence of the density of the gas and its absorbability by the liquid film.

- 364.** 1875. ANDREWS, TH. Preliminary notice of further researches on the Physical properties of matter in the liquid and gaseous states under varied conditions of pressure and temperature. *Proc. Roy. Soc.*, Vol. 23, p. 514-21, (1875.) Also see *Phil. Mag.*, (5) Vol. 1, p. 78-84, (1876.) and *Ann. Chim. Phys.*, (5) Vol. 8, p. 555-60, (1876.)

The laws of Boyle, Gay-Lussac and Dalton are applicable only to gases far distant from their critical points and are absolutely invalid for strong pressures; e. g., Carbonic acid gas at 63.7° C, when subjected to a pressure of 223 atmospheres yields a volume about half of that predicted by Boyle's law.

- 365.** 1875. MENSBRUGGHE, VAN DER. La Théorie capillaire de Gauss et l'extension d'un liquide sur un autre. *Bull. Brux.*, Vol. 39, p. 375-384.

Not accessible.

- 366.** 1876. GUEROUT, AUG. Recherches sur le coefficient d'écoulement capillaire. *Comptes Rendus*, Vol. 81, p. 1025, (1875,) and Vol. 83, p. 1291, (1876.) See also *Jour. Chem. Soc. Abst.*, 1877, p. 573.

The "capillary mobility" (see No. 351,) was determined for certain alcohols of the fatty and certain hydrocarbons of the benzene series, but no general law became apparent. Methylalcohol has the highest, Amylalcohol the lowest degree of mobility of the first series examined.

The examination of fatty acids and a series of esters would indicate that isomeric bodies of similar chemical nature have coefficients closely alike, while there are considerable differences for example between the mobility of a fatty acid and an ester that is isomeric with it as e. g. between butyric acid (129.5) and ethyl acetate (450.3.)

- 367.** 1876. BECQUEREL, M. Note sur les réductions métalliques produites dans les espaces capillaires. *Comptes Rendus*, Vol. 82, p. 354.

A fissured tube containing a solution of the salt of a metal, e. g. Nitrate of Copper or Cobaltous chloride is placed into a solution of Sodium Sulfide. If the fissure is not too narrow, diffusion takes place and the sulfide of the metal forms on the side of the tube in contact with the metallic salt. The sulfide will spread around the fissure and cover the wall of the tube thus forming a capillary space between itself and the glass wall, which gives rise to chemical reduction and the formation of a brilliant coating of the metal, (see No. 350.) Variations of this experiment are described and its bearing upon physiological phenomena discussed.

- 368.** 1876. CHEVREUL, E. Note sur l'affinité capillaire. *Comptes Rendus*, Vol. 83, p. 682.

Beginning this line of studies in 1809, the author in 1821 called *capillary affinity* the force exhibited by certain bodies, e. g., charcoal, in abstracting odoriferous or coloring principles from solutions. Copper may thus be removed from water contaminated with it. The magnitude of this capillary affinity is determined by quantitative analysis of the solutions before and after the capillary reactions. The absorbent action of massicot or calcined litharge upon lime water, strontian water and baryta water are studied herein by the method indicated.

- 369.** 1876. WROBLEWSKI, S. VON. Ueber die Diffusion von Gasen durch absorbierende Substanzen. *Pogg. Ann.*, Vol. 158, p. 539-568.

For the diffusion of Carbonic acid gas and Hydrogen through a caoutchouc membrane, and for pressures ranging from 740 to 20 mm., the author finds that the velocity of diffusion of a given quantity of gas is in direct ratio to the pressure of the diffusing gas upon the membrane. This law was also found to hold good for mixtures of the gases mentioned.

- 370.** 1876. SONDDHAUSS, CARL. Ueber flüssige Lamellen. *Pogg. Ann.*, Vol. 157, p. 73-102.

Various liquids have the property of forming liquid films in different degrees, a subject already considered by Plateau. (See No. 200.)

By special contrivances (a metallic triangle one side being movable,) the film forming power of various liquids can be compared. The author especially used a series of 10 metallic rings varying in diameter from 1 to 6 cm., and a series of larger rings up to 25 cm. diameter, and therewith examined the behavior of 45 liquids as to their film-forming property. A 3 cm. ring produced a water film, a ring of 1.4 cm. a film of Benzol; a ring of 25 cm. a film of Saponin solution. (1 in 800 parts of water.)

- 371.** 1877. MENSBRUGGHE, G. VAN DER. On the Application of Thermodynamics to the Study of the variations of Potential Energy of Liquid Surfaces. *Phil. Mag.*, (5) Vol. 2, p. 450-458, from *Bull. Brux.*, Vol. 41, p. 769-783, (1876.) (Prelim. Comm.)

Two equations are deduced which express a general relation between thermal, electric and surface (capillary) phenomena. Each alteration of a liquid surface involves an alteration of its heat contents, viz. a lowering of temperature when the increase of surface is due to contact with a solid body not wetted by the liquid, and a rise of temperature in the converse case, e. g. when porous brick, or paper, or starch, etc., become wet with water.

Furthermore every variation of the temperature of the liquid surface involves a variation in the electrical difference, giving rise to a thermoelectric current when the circuit is closed. The laws arrived at are a generalization of G. Lippmann's two laws. (see No. 343.) The constant change of liquid surfaces being attended by variations in the electrical conditions is amply exemplified in nature.

- 372.** 1877. MENSBRUGGHE, G. VAN DER. Same subject as No. 371. Second Prelim. Comm. *Phil. Mag.*, (5) Vol. 4, p. 40-48, from *Bull. Brux.*, (5) Vol. 42, p. 21-34, (1876.)

To the two formulae of the former paper (see No. 371.) is added a third, expressing a relation between the specific heat and the surface modifications of a liquid. This third law is applied to special cases and explains numerous interesting phenomena, e. g. why minute drops of water forming clouds and mists can float in strata of air much below the freezing point without assuming the solid state; or why water resists congelation when enclosed in capillary tubes, (see No. 237.) or in organized tissues; or the curious anomaly observed by W. Spring, in the values for the specific heat of Rose's alloy near its maximum of density.

- 373.** 1877. LIPPMANN, G. Relation entre les propriétés électriques et capillaires d'une Surface de Mercure en contact avec différents liquides. *Ann. Chim. Phys.*, (5) Vol. 12, p. 265-276.

The view expressed by the author before (see No. 343.) as antagonized by Quincke, (see No. 355.) regarding the connection between capillary and electrical phenomena is here again succinctly stated and illustrated by some well-devised experiments.

For example, two vertical capillary tubes end each into a cup above and communicate below with a wider Glass tube, also vertical. The latter is filled with mercury, which then assumes the same height in both capillary tubes if they have the same diameter. Even height is also obtained when both cups are filled with the same liquid, e. g. dilute sulfuric acid. But add a small quantity of hydrochloric acid to the acid in one cup, and the depression in the tube below becomes much greater. The same level, however, is restored, when the liquids in both cups are connected by a siphon filled with acidulated water, which equalizes the electrical potential energy of both mercurial surfaces.

The author states the meaning of the phenomena observed as follows: When Mercury is in contact with water or aqueous solutions, the addition of small quantities of certain other bodies suffices to alter two physical properties of the surface of contact, viz. electrical difference and capillary constant. Their simultaneous variation is subject to a simple law: For each value of electric difference at the mercurial surface there exists one value for the constant of capillarity, and one only, and it is independent of the chemical composition of the liquid.



**374.** 1877. MAXWELL, J. C. Capillary Action. *Encyclopedia Britannica*.

**375.** 1877. BECQUEREL. Electrocapillary Phenomena. *Journ. Chem. Soc. Abst.*, 1877, p. 820, from *Comptes Rendus*, Vol. 85, p. 169-173.

The author continues his experiments on electrocapillary effects obtained by means of cracked tubes (see No. 367.) and finds that Bismuth trichloride connected with Sodium sulfide solution by a capillary fissure, is easily reduced to metallic Bismuth, the Sulfide being formed as an intermediary product. If pulverulent materials, e. g. sand or powdered charcoal are put into the metallic solution, a metallic deposit will form throughout the whole mass.

**376.** 1877. REINOLD, A. W. and RUECKER, A. W. On the thickness of Soap films. *Proc. Roy. Soc.*, 1877, Vol. 26, p. 334-345.

A liquid film of soap solution when held inclined, will finally display a black zone of evidently extreme thinness. The boundaries of this zone, and especially its lower edge are characterized by a sharp increase in the thickness of the soap film. The authors made use of Plateau's soap liquid (see No. 337.) and determined the thickness of the film and the black zone by electrical measurements. The thickness of the black zone is fairly uniform and amounts to only 12 millicenths of a millimeter. (Compare No. 228.)

**377.** 1877. VILLARI, E. De l'écoulement du mercure par des tubes capillaires. *Comptes Rendus*, Vol. 84, p. 83.

The author finds that when mercury passes through capillary tubes drop by drop, Poiseuille's law holds good, (see No. 162.) viz. that the quantity passing in a second is proportional to the pressure, proportional to the 4th power of the radius of the tube, and inversely proportional to the length of the tube, provided this length is above a certain minimum, which becomes less for narrower tubes and smaller pressures. It is also dependent on a certain constant which in turn depends on the nature of the wall and the opening.

**378.** 1877. QUINCKE, G. Ueber Diffusion, und ob Glas für Gase durchlässig ist oder nicht. *Pogg. Ann.*, Vol. 160, p. 118-123.

Hydrogen gas generated in each of four V shaped glass tubes closed at both ends, exerted a pressure of 27 to 54 atmospheres in 5 months, and of 25 to 126 atmospheres in 17 years; yet neither of the glass apparatus lost in weight through possible diffusion of the gas through the glass. Glass tubes containing carbonic dioxide gas under great pressure behaved in the same manner. In the latter case, the concentrated sulfuric acid employed acquired an edge angle like that of mercury, due perhaps, to a layer of gas on the inner surface of the glass.

**379.** 1877. MOSER, JAMES. Ueber die Torricelli'sche Leere. *Pogg. Ann.*, Vol. 160, p. 138.

If Mercury in a barometric tube is almost entirely deprived of its air, it remains suspended from the top of the tube, not exhibiting the Torricellian Vacuum, unless a slight shock is given, then it drops to its usual height of atmospheric pressure, at the same time a bubble of air rises. By removing this air through successive especially devised operations, the author succeeded in keeping a column of 160 cm. of mercury suspended, thus reaching a high degree of rarefaction upon restoring the vacuum. Yet it is very difficult to remove *all* air. (Compare No. 172.)

**380.** 1877. QUINCKE, G. Ueber die Cohäsion von Salzlösungen. *Pogg. Ann.*, Vol. 160, p. 337-374, and p. 560-588.

The constants of capillarity of salt solutions were determined by two methods, observation of rise in capillary tubes, and measurement of flat air bubbles in these solutions. (see No. 312.) The latter method gave results about 1-9 higher. The results are given in lengthy tables and are in part stated as follows: Equivalent quantities of different chlorides having equal amount of chlorine, added to the same quantity of water or alcohol, gave salt solutions of nearly equal cohesion or surface tension, which increased nearly in proportion to the number of added salt equivalents. The constants increase with decreasing temperature and reach a maximum near the freezing points of the solutions. Among connected subjects herein discussed is the influence of magnetism upon the cohesion of fluids.

- 381.** 1877. JOHANNISJANZ, A. Ueber die Diffusion der Flüssigkeiten. *Wied. Ann.*, Vol. 2, p. 24-47.

The author concludes that the constant of diffusion between sodium chloride solution and water, if rather wide limits are allowed, is in accord with Fick's results, provided that diffusion taking place in the first twenty-four hours is disregarded. The author follows an ingeniously devised optical method suggested by Prof. Kundt, which permits the location at any moment of a given per centage of salt in the intermediary zone of diffusion. The march of diffusion can thus be conveniently and sharply observed. (Compare Nos. 294 and 393).

- 382.** 1877. QUINCKE, G. Ueber den Randwinkel, und über die Ausbreitung von Flüssigkeiten auf festen Körpern. *Wied. Ann.*, Vol. 2, p. 145-184.

If a solid body (1) is in contact with a liquid (2), and if both are bounded by a third fluid or gaseous medium (3), the equilibrium of the three surfaces of contact takes place according to the laws governing the common surface of two liquids, (see No. 312). The edge-angle formed in this manner is theoretically of definite value, (see No. 63), depending solely on the nature of the 3 substances and can be calculated from the 3 surface tensions intervening by a simple mathematical expression. (Compare No. 314). The surface tensions in question may be measured by the author's method of flat drops and bubbles. (See No. 312).

The edge-angle may also be measured directly by means of reflected light. Practically, however, the edge-angle is subject to changes, due to the influence of an extremely thin film of solid or liquid or gaseous substance in contact with the solid. The edge-angle of pure water, alcohol etc., against scrupulously clean glass or metallic surfaces seems to be zero, consequently these fluids spread upon the solid surfaces mentioned. A lengthy summary of the paper is given.

- 383.** 1877. HAGA, H. Ueber die durch das Strömen von Wasser in Capillarröhren erzeugte electromotorische Kraft. *Wied. Ann.* Vol. 2, p. 326-335.

The potential difference produced by the flow of water through such capillary tubes for which Poiseuille's law (see No. 162), holds good, is in direct ratio to the pressure, independent of the length of the tubes, dependent on the condition of the inner wall of the tube, and increases with the resistance of water and probably also with temperature. These phenomena were discovered by Quincke in 1859, and studied in this special direction by Zoeliner in 1872.

- 384.** 1877. CLARK, J. W. Ueber die beim Durchströmen von Wasser durch Capillarröhren erzeugte electromotorische Kraft. *Wied. Ann.* Vol. 2, p. 335-346.

The pressing of liquids through capillary tubes produces an electromotive force which increases with decreasing diameter of the tube. With very narrow tubes it decreases with their length. Lining the wall with different substances produces different values for the electromotive force. This force decreases with time. Its seat is in the liquid layer in contact with the wall of the tube. (See No. 383).

- 385.** 1878. ROENTGEN, W. C. Mittheilungen einiger Versuche über Capillarität. *Wied. Ann.* Vol. 3, p. 321-328.

Wilhelm's theory (see No. 286), that solids dipping into liquids, condense upon their surface a liquid layer of greater density than the rest of the fluid, is herein demonstrated to be untenable. A piece of gypsum suspended in water from the beam of a fine balance and tared, was split into eleven thin lamellae which increased the surface 11 times. Wilhelm's theory and calculations would involve a corresponding increase in weight by 216 mg. But the weight remained unchanged. A negative result was likewise obtained when determining the specific gravity of fine glass films of known weight and approximately known surface. (Also see Nos. 407 and 410).

The author furthermore describes a new method of measuring the difference in surface tensions of a caoutchouc membrane towards air and towards water.

- 386.** 1878. KOLACEK, V. T. Ueber den Einfluss des capillaren Oberflächendruckes auf die Fortpflanzungsgeschwindigkeit von Wasserwellen. *Wied. Ann.* Vol. 5, p. 425-430, and Vol. 6, (1879) p. 616.

- 387.** 1878. TERQUEM, A. Sur la production des systèmes laminaires de Plateau. *Comptes Rendus*, Vol. 86, p. 1057.

Unlike Plateau who employed rigid systems of metallic wires to produce soap films, (see No. 200.) the author employs flexible systems (two horizontal wires connected by two vertical flexible threads. When the system contains a liquid film (soap-syrup solution,) the surface tension causes the lower wire to be raised and the threads to assume the form of curves. Measurement of the tensile weight of the lower wire and the dimensions of the film permit the calculation of its surface tension.

- 388.** 1878. SONDHAUSS, CARL. Ueber die Spannung flüssiger Lamellen. *Pogg. Ann., Ergänzungsband*, VIII, p. 266-298.

The surface tension of liquid films may be determined by means of the balance; (compare Nos. 18 and 36.) a horizontal metallic ring suspended from one arm of the balance and dipping into the fluid to be examined, raises a cylindrical liquid film, whose tension is determined by the weight just sufficient to tear it asunder. The constant of capillarity calculated therefrom is checked by observations of the rise of the same liquids in capillary tubes. The surface tension of water, soap water, solution of saponin, and of mercury was thus determined and compared with the results of other investigators.

- 389.** 1878. DUCLAUX, E. Sur la tension superficielle dans la série des alcools et des acides gras. *Ann. Chim. Phys.*, (5) Vol. 13, p. 76-101.

The author briefly reviews the results of Simon, (see No. 202,) Buliginski, (see No. 299,) Valson (see No. 311,) and Quincke, (see No. 380.) He then determines surface tension of Alcohols and volatile fatty acids by means of 2 methods, viz. capillary rise and counting drops of the various fluids contained in a given volume capable of yielding exactly 100 drops of water. The surface tension of water is taken as unit. The surface tensions in each case DECREASE with increasing percentage of the aqueous solutions; a nearly parabolic curve represents the march. Amylic alcohol reduces the surface tension of water more markedly than all other alcohols. The law is found that: The percentage of each alcohol that has the same surface tension as amylalcohol, stands to the percentage of the latter in a constant proportion.

- 390.** 1878. THOMPSON, SILVANUS, P. On permanent Plateau's films. *Phil. Mag.*, (5) Vol. 5, p. 269-271.

These films are obtained by means of suitable wire frames (see No. 370,) dipped into a mixture of definite quantities of pure yellow rosin and Canada Balsam. The films obtained, when dried at an elevated temperature are so tough that they can sustain without breaking the pressure of a 50 gm. weight.

- 391.** 1878. LADENBURG, A. Untersuchungen über den absoluten Siedepunkt. *Berichte d. Deutsch. Chem. Ges.*, 1878, p. 818-822.

Directions to produce as a lecture experiment certain striking phenomena of the absolute boiling point (critical point) of liquid Sulfur dioxide are herein given; thus are exhibited the great coefficient of expansion of liquids near their absolute boiling point, (see Nos. 239 and 96.) the gradual flattening of the concave meniscus and the gradual vanishing of capillary elevation, both indicative of the decrease of cohesion with rising temperature; the formation upon the slow cooling of the gasified liquid, of a characteristic thick cloud of definite outline, within which the meniscus soon appears, and which marks the first sign of condensation. (see No. 414.) The absolute boiling points were determined for  $\text{SO}_2$ , ( $157$  to  $161^\circ \text{C}$ ., Drion, (see No. 239,) found  $140^\circ \text{C}$ .) Chlorine, ( $148^\circ \text{C}$ .) and Ether, ( $196^\circ \text{C}$ ., compare No. 218 and 96.) These values are not considered by the author to be final.

- 392.** 1878. STEFAN, J. On the diffusion of Carbonic acid through water and alcohol. *Phil. Mag.*, (5) Vol. 5, p. 476, from *Wien. Acad. Wiss.*, 1878.

Carbonic acid gas separated from air by a liquid cylinder diffuses through the latter, the rate of diffusion being constant if the pressure is maintained constant. A number of laws of diffusibility are similarly developed. The velocities with which gases spread in liquids are of the same order as the diffusion velocities of salts with these liquids as solvents. O and N diffuse faster through Water and Alcohol than  $\text{CO}_2$ , Hydrogen diffuses fastest. (Compare No. 130.) Absorbability of gas by liquid only determines the density of the diffusion current, not its velocity; the latter is governed by the greater or lesser density of the diffusing gas.



- 393.** 1878. STEFAN, J. On the Diffusion of Liquids. *Phil. Mag.*, (5) Vol. 7, p. 74-75, from *Wien. Acad. Wiss.*, 1878.

The results of E. Voit and Hoppe Seyler on the diffusion of sugar solutions by saccharimetric methods are discussed and compared with Fick's theory of diffusion. The deviations observed especially in the results of the optical method by Johannisjanz, (see No. 381.) are due to the fact proved by the author that a horizontal beam of light traversing a vertical plane bounding a diffusing liquid, does not remain horizontal during its passage, but is deflected.

- 394.** 1879. STEFAN, J. On the Diffusion of Liquids. *Phil. Mag.*, (5) Vol. 7, p. 295-297, from *Wien. Acad. Wiss.*, 1879, p. 24.

Graham's results (see No. 198.) are formulated into a mathematical expression. Tables are given showing in parallel columns the salt contents in the various layers as observed by Graham, and calculated by the author, both series of values agreeing remarkably well in several series of diffusing salts. Several coefficients of diffusion at definite temperatures are recorded e. g. for Caramel, Albumen, Cane Sugar, NaCl, HCl.

- 395.** 1879. WEBER, H. F. Untersuchungen über das Elementargesetz der Diffusion. *Wied. Ann.*, Vol. 7, p. 469-487 and 536-552.

The author establishes the correctness of A. Fick's elementary law of diffusion (see No. 214.) and declares it analogous to Fourier's law of conduction of heat in solid bodies. Two extremely accurate and sensitive methods of measuring the march of diffusion by measuring electromotive forces are introduced, based upon the observation that the electromotive force between two plates of zinc which are electrodes of superposed zinc sulfate solutions of different concentrations, is within moderate intervals of concentration proportional to the difference of concentration of both liquids. The disturbing influence of temperature in these phenomena is shown with great accuracy by these methods.

- 396.** 1879. CHAPPUIS, P. Ueber die Verdichtung der Gase auf Glasoberflächen. *Wied. Ann.*, Vol. 8, p. 1-29.

The author followed the principle of Magnus of determining the amount of gas held by a glass surface, i.e. measuring the volume of gas at constant pressure evolved from a large and known surface, by exposing the latter to temperatures from 0° to 180° C. Thus values were obtained for Hydrogen, Air, CO<sub>2</sub>, SO<sub>2</sub> and NH<sub>3</sub>. Incidentally the coefficient of expansion of Ammonia gas at constant pressure was determined for the first time, for temperatures ranging from 0° to 180° C.

- 397.** 1879. MOHR. Ueber die Natur der Cohäsion und ihre chemische Bedeutung. *Lieb. Ann.*, Vol. 196, p. 183-213.

An earnest arraignment of the atomistic theory and certain consequences drawn therefrom (such as the explanation of isomerism by presuming the existence of a difference in the concatenation of atoms within the molecule, etc.) He charges this theory with ignoring the heat phenomena in bodies, and demands the application of the law of the conservation of energy to chemical processes also. The force of Cohesion the author refers to the wave theory, and adduces numerous examples ingeniously collated to illustrate his point.

- 398.** 1879. MOUSSON, ALB. *Die Physik auf Grundlage der Erfahrung*, 3 Vols., Zürich, 1879-1882.

Vol. I, p. 264-302, considers the Cohesion of Liquids and Capillarity.

- 399.** 1879. MENSBRUGGHE, VAN DER. Sur le problème des liquides superposés dans un tube capillaire. *Mém. Couronn. Brux.*, Vol. 41, (1878,) No. 1. Also see *Ann. Phys. Chem. Beiblätter*, Vol. 3, (1879,) p. 772-775.

Not accessible.

- 400.** 1879. FITZGERALD, GEO. FR. On the Tension of Vapors near curved surfaces of their liquids *Phil. Mag.*, (5) Vol. 8, p. 382-384.

The connection of Sir W. Thomson's theory of Vapor tension at curved Surfaces (see No. 819.) with the theory of Evaporation is pointed out.

- 401.** 1879. MENSBRUGGHE, VAN DER. Du rôle de la surface libre de l'eau dans l'économie de la nature. *Assoc. Franç. Comptes Rendus*, 1879, p. 553-561.

Not accessible.

- 402.** 1879. RAYLEIGH, LORD. On the Capillary phenomena of Jets. *Proc. Roy. Soc.*, Vol. 29, p. 71-97.

The remarkable periodic contractions taking place in a liquid jet issuing from orifices of various shapes, are dominated by capillary force, a fact recognized by H. Buff in 1857. The author calls *wave-length*, the length of the jet between two such recurring contractions. A jet of methylated alcohol has twice the wave length of water under otherwise equal conditions, which is due to the inferior capillarity of the former. A mathematical relation between wave-length, surface tension, specific gravity, cross section and pressure is established and verified by experiment. Capillarity also becomes evident in cases where a cylindrical jet issuing from a circular orifice resolves itself into globular masses, (see No. 200.)

- 403.** 1879. RODENBECK, HERMANN. *Ueber Capillaritätsbestimmungen von Flüssigkeitsgemischen*. Dissert., Bonn. 62 pp.

If two liquids are mixed in varying proportions and if a curve is constructed by taking the specific gravities of the mixtures as abscissae, and by taking as ordinates the constants of capillarity herein defined as the square root of the specific cohesion (see No. 302,) measured at constant temperature, a striking difference will become evident between such pairs of liquids as contract, and such as do not contract in volume upon being mixed. The former class (e. g. alcohol and water,) present a non-linear curve, while the second class (e. g. Ether and Chloroform,) present a straight line. The constant of capillarity of the non-contracting mixture can be calculated from those of its constituents by a simple relation obtainable by merely applying the rules of alligation. The formula for the constant of capillarity for mixtures of contracting liquids, however, must be empirically determined for each particular pair of liquids, and was ascertained by the Author for alcohol and water.

- 404.** 1879. MENSBRUGGHE, VAN DER. Remarques sur la mesure de la tension superficielle des liquides. *Journal de Physique*, Vol. 8, p. 52-57.

Not accessible.

- 405.** 1880. NOACK, KARL. *Experimental-Untersuchungen über die Steighöhen von Wasser und Alcohol*. Dissert. Giessen, 35 pp.

The capillary heights of rise of water and alcohol at certain definite temperatures between  $0^{\circ}$  and  $190^{\circ}$  C are measured and tabulated, and an empirical formula is established, showing the variation of the Constants of Capillarity with temperature. The capillary rise of mixtures of alcohol and water is also considered. (Compare No. 403.)

- 406.** 1880. LONG, J. H. *Ueber Diffusion von Salzen in wässeriger Lösung*. *Wied. Ann.*, Vol. 9, p. 613-641.

By means of a specially devised apparatus the salt solution constantly diffuses into pure water, the diffusate being carried off at a steady rate (say 30 cc per hour.) An equilibrium of diffusion does not establish itself until after the first twenty-four hours. Diffusive value increases more rapidly than does concentration. (Beilstein.) The author calculated the *relative molecular diffusion* which is the quantity of diffusion in twenty-four hours divided by molecular weight. Thus, the relative number of molecules diffused is about the same for KCy, KCl, K Br. and K I., their conductivity also being identical. Kohlrausch having found identical conductivity

for HCl, H Br, H I and  $\text{HNO}_3$ , the author calculated from Graham's results, (see No. 188,) the relative molecular diffusion of each of these substances and found them also to be nearly identical. The author in this connection theorizes on the constitution of solutions, and mentions Schuhmeister's researches who concluded (1879) that Salt solutions form the same series when classified according to conductivity, inner friction and diffusibility.

- 407.** 1880. SCHLEIERMACHER, AUG. Ueber die auf einem benetzten Körper verdichtete Flüssigkeitsmenge. *Wied. Ann.*, Vol. 8, p. 52-83.

The author does not deny that a solid dipping into a fluid may condense a liquid layer of greater density upon its surface, (see No. 114,) but pronounces the numerical value of this condensation given by Wilhelmy to be by far too high. He concludes from experiments partly similar to those of Roentgen, (see No. 385) that the influence of condensation may safely be neglected in the determination of specific gravities, if no higher degree of accuracy than 0.002 per cent. be a consideration.

- 408.** 1880. ROGER, E. Théorie des phénomènes capillaires. Fifth memoir. *Comptes Rendus*, Vol. 90, p. 908.

By theoretical considerations a formula expressing the law of molecular attraction is established, which includes the law of gravitation as a special case. Compare subsequently DE HEEN. (See No. 471.)

- 409.** 1880. HANNAY, J. B. On the State of Fluids at their Critical Temperatures. *Proc. Roy. Soc.*, Vol. XXX, (1879-80,) p. 478-484.

The author places a light gas, e. g. Hydrogen, above the liquid to be tested for its properties near its critical point, in order to enable a better observation of these phenomena, because a sharp line of demarcation remains thereby established whether the liquid be below or above its critical point, (i. e. gasified.) In the first case, slight reduction of pressure will effect boiling of the liquid, while in the second case the gasified liquid responds by merely expanding. Alcohol was observed to boil at  $1^\circ \text{C}$  below its critical temperature, and to expand at  $1^\circ \text{C}$  above, expansion took place whether the pressure was 50 or 200 atmospheres.

Again, the capillary height of a column of  $\text{CS}_2$  becomes zero at the critical point, whether the pressure is 80 or 140 atmospheres. Thus, experimental proof is furnished of the fact that cohesion in liquids decreases upon warming and disappears altogether at the critical temperature, not being restored by increase of pressure.

- 410.** 1880. VOLKMANN, P. Ueber den Einfluss der Krümmung der Wand auf die Capillaritätsconstante bei benetzenden Flüssigkeiten. *Wied. Ann.*, Vol. 11, p. 177.

An influence of the curvature of the wall of a glass vessel upon the constant of capillarity of a liquid with which it is in contact, as claimed by Wilhelmy (see No. 279,) does not exist, at least not to such an appreciable extent as this author believed. Wilhelmy's erroneous result may be traced to and fully explained by the erroneous assumption that the specific gravity for alcohol is  $0.793^\circ \text{C}$ , while it actually is  $0.793$  at  $0^\circ \text{C}$ . and  $0.782$  at  $17.5^\circ \text{C}$ .

Parallel plates and tubes of glass were used to observe and measure the capillary rise of Alcohol and "Klauefett" which easily retain their capillary purity and therefore give constant results. The author observes that when the glass is perfectly wetted by the liquid, the latter rises along a liquid layer of constant thickness, which the author has found for these liquids to be  $0.004 \text{ mm}$ .

- 411.** 1880. LIPPMANN, GAB. Bemerkungen über einige neuere electropillare Versuche. *Wied. Ann.*, Vol. 11, p. 316-324.

The author reaffirms his former conclusions (see No. 373,) against experimental criticisms by L. Grätz and by Quincke, and points out that the extreme sensitiveness of his capillary electrometer (see No. 343,) and its usefulness in measuring exceedingly small electromotive forces is also recognized by other authors.



- 412.** 1880. OBERBECK, A. Ueber die Reibung in freien Flüssigkeits-  
oberflächen. *Wied. Ann.*, Vol. 11, p. 634-652.

A rectangular vertical brass plate delicately suspended in the liquids to be examined was made to oscillate around its axis, first with the upper edge of the plate entirely in the liquid, then exceedingly near the surface, and thirdly slightly above the surface. If a surface friction exists, it must exert its influence upon the oscillations of the plate.

With all liquids examined, the resistance rises appreciably when the plate approaches the surface. Upon further elevation, when the upper edge falls within the liquid surface, the various liquids exhibit characteristic differences in the exact manner as described by Plateau (see No. 321,) as follows:

1. Liquids exhibiting considerable increase of resistance. Water and aqueous salt solutions.
2. Liquids exhibiting decrease of resistance. Alcohol, alcoholic solutions, carbondisulfide, oil of turpentine.
3. Mixtures of alcohol and water leaning towards one or the other group, according to their relative proportions.

- 413.** 1880. MENSBRUGGHE, VAN DER. Voyages et métamorphoses  
d'une gouttelette d'eau. *Bull. Brux.*, Vol. 50, p. 423-447.

Not accessible.

- 414.** 1880. CLARK, J. W. On the behavior of Liquids and Gases near  
their Critical Temperatures. *Phil. Mag.*, (5) Vol. 10, p. 145-155.

When a sealed glass tube containing a capillary tube which dips into Alcohol, Ether or Carbondisulfide, is gradually heated, the liquid sinks in the capillary and rises by expansion in the outer tube.

Within  $2^{\circ}$  or  $3^{\circ}$  C. below the critical temperatures of these liquids, both surfaces become level. When the end of the capillary tube dips but slightly below the surface of the liquid, the meniscus does not sink below the outer level as it might do otherwise, but is level at the moment of the disappearance of the liquid.

At temperatures very near the critical, the densities of liquid and vapor are nearly equal; when contained in closed U tubes, and the heating is one-sided, the entire disappearance of the liquid from one branch of the tube does not affect its level in the other. A detailed summary is given. (Compare No. 95, 218 and 318.)

- 415.** 1881. WAALS, J. VAN DER. *Die Continuität des gasförmigen und  
flüssigen Zustandes.* Transl. and additions made by Dr. Friedr.  
Roth, Leipzig, 1881, 168 pp.

This celebrated treatise on the Continuity of the gaseous and liquid states of matter owes its existence to the author's desire to arrive, through theoretical considerations, at numerical values for the constant  $K$  in Laplace's theory of Capillarity, (see No. 64.) This constant represents the molecular pressure upon the unit of liquid surface hence a measure of cohesion, and was supposed by Laplace to be immensely high. For Ether the author calculates a pressure of about 1,300 atmospheres, for water 10,500 atmospheres along one millimeter's length. The author records Bosscha's experiments which prove the existence of a surface tension and the possibility of capillary phenomena even for tobacco smoke and water vapor. To this the author adds his own experience to the effect that in moistened capillary tubes, foggy vapors exhibit a meniscus and are depressed like Mercury; this phenomenon is especially striking in a capillary U tube, one limb of which is moistened while the other is dry.

- 416.** 1881. HANNAY, J. B. On the Limit of the Liquid State. *Proc.  
Roy. Soc.*, Vol. XXXI, 1880-81, p. 520-522.

In this paper the phenomena of the critical temperature for  $\text{CS}_2$ , Alcohol and Methyl alcohol (see No. 391,) are studied by observing the decrease of capillary rise at increasing temperatures. The results obtained are illustrated by curves.

- 417.** 1881. KUNDT, A. Ueber den Einfluss des Druckes auf die Ober-  
flächenspannung an der gemeinschaftlichen Trennungsfläche  
von Flüssigkeiten und Gasen. *Wied. Ann.*, Vol. 12, p. 538-550.

Th. Andrews had found (*Phil. Mag.*, (5) Vol. I, p. 78, 1876,) that the critical point of a gas is lowered by the admixture of a noncondensable gas. Caillietet (*Comptes Rendus*, 1880, Vol. 90, p. 210,) liquefied a mixture of  $\text{CO}_2$  and 1.5 air at temperatures below  $26^\circ \text{C}$ . When increasing the pressure to 150-200 atmospheres, the meniscus of the liquid became more and more flat and finally the liquid was "dissolved in the gas." (See Nos. 95 and 96.)

The author reasons that any ordinary liquid or solid may thus be gasified and its surface tension lowered by pressing into it a gas which is above its critical temperature; provided the pressure is immensely high. But the decrease of surface tension (the lowering of the capillary height of rise of the liquid,) can be watched within experimental limits. Pressure with air reduces surface tension more rapidly than with Hydrogen. An interesting summary of results is given.

- 418.** 1881. WROBLEWSKI, S. VON. Ueber die Anwendung der Photometrie auf das Studium an Diffusionserscheinungen an den Flüssigkeiten. *Wied. Ann.*, Vol. 13, p. 606-623.

The process of diffusion is not only governed by the molecular velocities of both fluids, but also by molecular forces causing variable contraction. Such variation takes place for example according to whether water is in contact with a concentrated or with a dilute solution of salt. Thus the coefficient of diffusion cannot be considered a constant quantity; it assumes a special value for each case of experiment, hence the discrepancies of this value in the literature on the subject. The author especially measured the diffusion of exceedingly dilute salt solution into pure water colored by the optically permanent Nigrosin. The march of diffusion was studied by means of a spectro-photometer. The constant of diffusion in this case was found to be one-tenth of the lowest on record.

- 419.** 1881. JOULIN, L. Recherches expérimentales sur la diffusion. *Ann. Chim. Phys.*, (5) Vol. 22, p. 398-421.

The work is summarized in 3 tables dealing with 1st, the absorption of dry gases ( $\text{CO}_2$ ,  $\text{N}_2$ ,  $\text{O}_2$ ,  $\text{NH}_3$ ,  $\text{H}_2$ ) by charcoal at temperatures from  $-20^\circ$  to  $255^\circ \text{C}$ , and pressures from a few cem. of Mercury to 4 atmospheres. 2nd the absorption of mixtures of dry gases by charcoal, and 3rd, the quantity of exchange between the gas condensed on charcoal and that of its containing vessel.

- 420.** 1881. HOPPE-SEYLER, FELIX. *Physiologische Chemie.*, 4 Vols., Berlin, 1878-1881.

In Vol. I is contained (p. 140-148) a chapter on the Diffusion of Liquids which is a summary review of the researches of Graham (see No. 198) Beilstein, (*Ann. Chem. Pharm.*, Vol. 89, p. 165,) A. Fick, (see No. 214,) Simmler and Wild, (See No. 223,) E. Voit, (see No. 294,) and the author himself. Further chapters (p. 150-174,) are on Filtration, Transsudation, Imbibition and Osmosis.

- 421.** 1881. HART, S. L. On some Capillo-Chemical effects. *Phil. Mag.*, (5) Vol. 12, p. 324-340.

Studied the generation of electricity under varying conditions, in a body of mercury contained in a funnel with long stem ending in a fine point; he finds that the advancing drop becomes positively charged, while the retreating end is charged negatively and becomes oxidized by prolonged action. Fanning the surface of the mercury increased the deflection, while substitution of the surrounding air by coal gas caused the deflection to be reduced to zero.

- 422.** 1882. KÖENIG, A. Ueber die Beziehungen zwischen der galvanischen Polarisation und der Oberflächenspannung des Quecksilbers. *Wied. Ann.*, Vol. 16, p. 1-38.

A detailed list of references to the subject of the mutual relation between galvanic polarization and surface tension of mercury is given. Mercury was placed against various acid and salt solutions, etc., in a suitable apparatus which also allowed the necessary electrical measurements. The tabulated results show a maximum of surface tension for increasing values of electric potential, the maximum point varying with the different liquids.

- 423.** 1882. WROBLEWSKI, S. VON. Sur l' influence de la quantité du gaz dissous dans un liquide sur sa tension superficielle. *Comptes Rendus*, Vol. 95, p. 284-287; also see *Phil. Mag.*, (5) Vol. 14, p. 327-328.

The author shows Kundt's interpretation (see No. 417) of the decrease of surface tension with pressure to be wrong. The decrease is merely a secondary effect. The primary cause consists in the absorption of gas by the surface layer, resulting in a decrease of surface tension with increasing quantity of dissolved gas, hence secondarily with increasing pressure. This was shown by the author with  $\text{CO}_2$  at pressures from 1 to 30 atmospheres. In Kundt's opinion, cohesion (surface tension) would be lowered with increasing temperature, but the opposite takes place; i. e., when the pressure (above one atmosphere) remains unchanged, increase in temperature will lower saturation power for gas, hence will increase surface tension. It is shown that as solubility does not keep pace with increasing pressure, the surface tension of water saturated with  $\text{CO}_2$  will approach a limit which at  $0^\circ$  is reached at the pressure required to liquefy  $\text{CO}_2$ . At this point the surface tension of the supernatant waterstratum is reduced to about one-half.

- 424.** 1882. WROBLEWSKI, S. VON. Sur la tension superficielle de quelques liquides au contact de l'acide carbonique. *Comptes Rendus*, Vol. 95, p. 342-343; also see *Phil. Mag.*, (5) Vol. 14, p. 327-328.

When alcohol, oil of turpentine, ether or chloroform, which are liquids miscible with liquid carbon dioxide, are saturated under increasing pressure with the gas, the surface tension of each liquid will diminish with increasing pressure; the rate of diminution is much greater at a lower than at a higher temperature. But the surface tension, instead of stopping at a minimum (see No. 423), falls rapidly, and at  $0^\circ \text{C}$ , under the pressure at which  $\text{CO}_2$  is liquefied, all the liquids mentioned, uniformly have the low surface tension of carbon dioxide.

- 425.** 1882. PLATEAU, J. J. A little illusion. *Phil. Mag.*, (5) Vol. 13, p. 379.

Given a water surface, a capillary tube of moderate width dipping into it under an angle of about  $40^\circ$ , and a smaller capillary siphon attempting to remove the water from the top of the capillary tube into the surface immediately below. No water will drop from the capillary siphon, because the capillary action exerted by the curved surfaces concerned is greater than the gravity of the acting water column in the siphon.

- 426.** 1882. VOLKMANN, P. Ueber die Molecularanziehung von Flüssigkeiten auf einander. *Wied. Ann.*, Vol. 16, p. 321-335.

In immiscible liquids, the surface tension of the common surface is less than the arithmetic means of the surface tensions of both liquids considered separately; in miscible liquids, the surface tension of the common surface is either equal to [ether-chloroform, ether-petroleum] or greater than [petroleum-chloroform, alcohol-chloroform] the arithmetic means of the individual surface tensions. For such miscible liquids as do not contract upon being mixed, the resultant surface tension (total cohesion) is expressed in terms of the tension of their common surface, the two individual surface tensions and the constituting volumes of the mixture. The correctness of the formula is verified by means of the results obtained by Quincke and Rodenbeck (see Nos. 312 and 403).

- 427.** 1882. VOLKMANN, P. Ueber die Cohäsion von Salzlösungen. *Wied. Ann.*, Vol. 17, p. 353-370.

The solubility of salt in water is analogous to the miscibility of liquids, and an analogous formula is given (see No. 426). The "specific cohesion" of a salt solution (equivalent to the height of capillary rise in one and the same tube) decreases steadily with increasing percentage of salt, while the "real cohesion" (surface tension) increases nearly in proportion to the salt contents. Small quantities of *soluble* impurities do not materially affect cohesion or surface tension of salt solutions or even water.



- 428.** 1883. VOLKMANN, P. Beobachtungen an fallenden Quecksilbertropfen. *Wied. Ann.*, Vol. 19, p. 66-70.

A drop of mercury, growing at the lower orifice of a vertical capillary tube, forms with the horizontal plane decreasing angles until a minimum value is reached, but does not quite attain the usual edge-angle of mercury for glass ( $30^{\circ}$ - $45^{\circ}$ ). Upon further growth of the drop, the angle again increases, until at  $90^{\circ}$ , according to the author, it has reached the limit of its stability. This state he calls the "largest" drop, and that immediately following the "falling" drop. The surface tension of mercury is calculated from measurements of the height of the "largest" drop, the height of the remaining drop, the diameter of the tube at the point of exit, and the weight of the falling drop.

- 429.** 1883. ROENTGEN, W. C. Ueber einen Vorlesungsapparat zur Demonstration des Poiseuille'schen Gesetzes. *Wied. Ann.*, Vol. 20, p. 268-271.

By an ingenious contrivance tinted water is allowed to flow from a high, constant level through two consecutive capillary tubes of equal length and diameter; one vertical manometric tube being inserted before the first, another between the two capillary tubes. Under this condition, the water stands twice as high in the first as in the second manometric tube. In replacing the second capillary tube by one of half its length but of same diameter, or by one of equal length but half the diameter, the manometric pressures again adjust themselves in exact accordance with Poiseuille's law (see No. 162).

- 430.** 1883. BUNSEN, R. Ueber die Adsorption von Kohlensäure in Glas. *Wied. Ann.*, Vol 20, p. 545-560.

Contrary to accepted opinions, Bunsen observed that great surfaces of glass (in the form of fine glass threads) absorb  $\text{CO}_2$  in appreciable quantity, but slowly; the absorption is not completed in three years. Increased temperature increases adsorption; changes of pressure do not materially affect the phenomenon (see No. 447).

- 431.** 1883. BASHFORTH, FRANCIS. *An attempt to test the Theories of Capillary Action by comparing the Theoretical and Measured Forms of Drops of Fluid.* Cambridge, 1883.

The calculations embodied in this painstaking work were completed in 1857. Chapters 1st and 2nd give an historical review of the theories and experimental tests of capillarity. Chapter 3rd contains the elaborate calculation of the theoretical forms of drops of fluid under the influence of capillary action. Assisted in by J. C. Adams. Chapter 4th treats of the comparison of calculated and measured forms of drops, with tables, and the appendix (completed in 1862) treats of the determination of capillary constants of mercury in contact with glass; ending with tables.

The reliability and usefulness of these tabulated data are acknowledged by recent writers on capillarity (see e. g., SIEDENTOPF, 1897).

- 432.** 1883. LE CONTE, JOHN. Apparent Attractions and Repulsions of Small Floating Bodies. *Phil. Mag.*, (5) Vol. 15, p. 47-56.

The full history of these phenomena, as treated by various authors since Mariotte (1655), is given. The explanation is based on the following two propositions: "Both in the case of wetting and non-wetting of the solid by the liquid, an adhesion exists between solid and liquid. The capillary forces are in any given case inversely proportional to the radii of curvature of the menisci, and their resultants are directed toward the centers of concavity." The primary cause of the phenomena of attraction and repulsion lies in the existence of a tensile surface film, upon which the curvatures of the menisci act as disturbances (see No. 446).

- 433.** 1883. RILEY, JOHN T. On Capillary Phenomena. *Phil. Mag.*, (5) Vol. 15, p. 191-198.

The molecular pressure  $K$ , due to a plane surface, which figures so prominently in the capillary theory of Laplace (see No. 71), according to the author is either non-existent or but very small. This view he supports by an experiment. The basis of all capillary phenomena is the existence of a surface tension uniform

in all directions in the free surface; when in contact with a solid, its numerical value is modified by the hydrostatic elevation or depression of the liquid. The phenomena of capillary attraction and repulsion, discussed by Le Conte (see No. 432), are secondary results of surface tension, and are produced by modified hydrostatic pressures. The existence of a definite angle of contact is also a result of surface tension.

- 434.** 1883. WORTHINGTON, A. M. On the Horizontal Motion of Floating Bodies. *Phil. Mag.*, (5) Vol. 15, p. 198-203.

The horizontal motion of floating bodies (see Nos. 432 and 433) is explained by the author by taking into principal account the horizontal components of capillary forces, deducible from the principles of a definite surface tension, a definite angle of contact, and the hydrostatic pressure when the surfaces are depressed by capillarity, or hydrostatic tension when the surfaces are raised above the surrounding level.

- 435.** 1883. STABLES, W. H., and WILSON, A. E. Experiments on the Viscosity of a Solution of Saponine. *Phil. Mag.*, (5) Vol. 15, p. 406-414.

Circular disks were allowed to swing within or a little below the surface of water and saponine solutions, and the relative resistances were noted (apparatus of Grottrian, *Pogg. Ann.*, Vol. 157, p. 237). At the surface of a 2% saponine solution, the resistance is at least 600 times greater than in the interior; the ratio is reduced to 16 times by immersing the upper surface of the disk to a depth of 0.1 mm. (compare No. 412).

- 436.** 1883. WIEDEMANN, E. On the condensation of Fluids on Solid Bodies. *Phil. Mag.*, (5) Vol. 15, p. 440. From *Wied. Ann.*, Vol. 17 (1882), p. 988-990.

Wilhelmy's conclusions as to a condensation of liquids on solid bodies having been disproved by Roentgen, Schleiermacher and Volkmann (see Nos. 279, 385, 407 and 410), the author deduces from Van der Waals's theory on the magnitude of molecular forces (see No. 415) the weight of such a fluid layer to be less than  $25 \times 10^{-8}$  grammes; hence a wholly negligible quantity.

- 437.** 1883. REINOLD, A. W., and RUECKER, A. W. On the Limiting Thickness of Liquid Films. *Phil. Trans.*, 1883, No. 174, p. 645-662.

Two completely independent methods (electrical and optical) of measuring the thickness of the black portions of a soap film (see No. 376) give concordant results. They vary between 7.2 and 14.5 millionths of a millimeter. The average value is 11.6 millionths of a millimeter.

- 438.** 1883. KROUCHKOLL. Variation of the Constants of Capillarity of the Surfaces Water-Ether and Water-Carbondisulphide under the Action of Electromotive Force. *Jour. Chem. Soc. Abst.*, 1883, p. 1047, from *Comptes Rendus*, Vol. 96, p. 1725-1728.

The author finds that *insulating liquids*, such as carbon disulphide, ether, turpentine, acquire a distinct conductivity in contact with water, capable of being demonstrated by Lippmann's electrometer (see No. 343). Lippmann's well-known experiments with mercury can thus be repeated with ether or with carbon disulphide, although the effects are much retarded.

- 439.** 1883. SCHIFF, R. Constant of Capillarity of Liquids at their Boiling Points. *Jour. Chem. Soc. Abst.*, 1883, p. 549, from *Ber. d. Deutsch. Chem. Ges.*, Vol. 15, p. 2965-2975.

The constant of capillarity (surface tension) for a number of organic liquids at their boiling points was determined by measuring the height of rise of the liquid in the capillary limb of the tube, the apparatus being suspended in the vapors of the same liquid at boiling temperature.

- 440.** 1883. RAMSAY, WILLIAM. On the Critical Point of Liquefiable Gases. *Phil. Mag.*, (5) Vol. 16, p. 118-120.

The critical point of a liquid is here defined as that point at which the liquid, owing to its expansion, and its vapor, owing to compression, acquire the same specific gravity, and consequently mix with each other. The paper is a priority claim against Jamin.

- 441.** 1883. RAYLEIGH, LORD. On Laplace's Theory of Capillarity. *Phil. Mag.*, (5) Vol. 16, p. 309-315.

Theoretical considerations on the constitution of liquids and the nature of capillary force. The author defends Laplace's assumption of the existence of an intense molecular pressure in liquids due to the plane surface (compare No. 433).

- 442.** 1883. WORTHINGTON, A. M. On Laplace's Theory of Capillarity. *Phil. Mag.*, (5) Vol. 16, p. 339-344.

Theoretical considerations.

- 443.** 1884. ———. The Ascent of Water in Plants. Editorial in *Nature*, Vol. XXX, p. 561-562.

BOEHM ascribes the rise of water in plants to the effect of atmospheric pressure upon a system of air-bubbles and water. SACHS has brought forth his *imbibition* theory; i. e., the imbibed water molecules are held between the complex cell molecules as salt is held in sea water. ELFFYNG's recent theory is based on the existence of Jamin's chapelets (see No. 242, which are permeable to water but not to air; the molecules of water can freely move without difficulty, and traveling towards the transpiration surfaces, can reach any height with the greatest ease (*siege theory*, so called).

- 444.** 1884. SCHIFF, ROBERT. Ueber die Capillaritätsconstanten der Flüssigkeiten bei ihrem Siedepunkt. *Lieb. Annal.*, Vol. 223, p. 47-106. Also see *Jour. Chem. Soc. Abst.*, 1884, p. 808.

The constant of capillarity (surface tension) of a liquid in capillary spaces is defined as the weight of the liquid suspended from the unit of length of the contact line of the meniscus. This constant is herein ascertained at the boiling point of the liquid, and the author divides its value by the molecular weight, thus obtaining a new capillary constant ( $= N$ ), which expresses the relative number of molecules suspended along the above-named unit of length.

Interpreting his tabulated results, the author discovers a remarkable capillary equivalency between the atoms of C, H, O and Cl; for example, the compounds  $C_6H_{14}$ ,  $C_5H_{10}$  and  $C_5H_{10}O_2$  have identical  $N$ , equal to 16; hence  $C_2$  is equivalent to  $H_4$ ,  $C_3$  equivalent to  $O_2$ . The same equivalents hold good in several other groups where  $N$  has a different value. The following equivalents are finally established  $C=H_2$ ,  $O=H_3$ ,  $Cl=H_7$ , which allows any organic formula containing C, H, O and Cl to be expressed in hydrogen equivalents. Taking the latter as abscissæ and the corresponding values for  $N$ , as found by experiment, as ordinates, a curve is constructed which permits this new constant of capillarity (relative number of raised molecules) to be deduced for any organic liquid not herein examined, from its mere chemical formula. An equation of the curve is also given. However, some interesting restrictions are indicated.

- 445.** 1884. CHERVET, ALFRED. Distribution du Potentiel dans des masses liquides de forme déterminée. *Ann. Chim. Phys.*, (6) Vol. 1, p. 256-283.

A rectangular body of copper-sulphate solution is traversed by an electric current. A general law is theoretically deduced, expressing the potential energy existing at any point of its surface. The law was then verified by touching different points of the surface with the ends of two wires leading to a sensitive capillary electrometer of special construction. The different compensating pressures thus required to bring the meniscus back to its zero point (compare No. 343) are tabulated and compared with the values calculated from the formula.



- 446.** 1884. LE CONTE, JOHN. Horizontal Motions of Small Floating Bodies in Relation to the Validity of the Postulates of the Theory of Capillarity. *Amer. Journal of Science*, (3) Vol. 27, p. 307-315.

The author's abnormal results in determining the height of rise of water in capillary tubes of various diameters, and between parallel plates whose distances were varied, lead him to antagonize the correctness of the fundamental postulates of the capillary theory as summarized by J. Clerk-Maxwell (see No. 374), and to favor the views expressed by Simon (see No. 202). From his tabulated results the author for example deduces that Jurin's law (see No. 16) fails to be even approximately verified when the diameter or the plate distance exceeds 0.2 cm. Surface tensions, which, according to the theory, should be a constant quantity for the same liquid at the same temperature and for all variations of diameter and height of rise and even variation of method, become approximately constant only at diameters below 0.2 cm., and decrease with increasing diameter; and the surface tension measured in tubes was to that measured with parallel plates as about  $\frac{1}{2} \times 3.1416 : 1$  (compare No. 202).

- 447.** 1884. KAYSER, H. Ueber die Verdichtung der Kohlensäure an blanken Glasflächen. *Wied. Ann.*, Vol. 21, p. 495.

Endeavoring to account for Bunsen's abnormal results (see No. 430), the author demonstrates by diffusion experiments that  $\text{CO}_2$  is liable to diffuse against air through a layer of fat that may be used in making ground glass stoppers gas-tight. In cases devoid of this influence, a maximum of absorption establishes itself shortly, and the gas volume then remains rigidly constant.

- 448.** 1884. ROTHER, O. Ueber Capillaritätsbestimmungen von Salzlösungen und deren Gemischen. *Wied. Ann.*, Vol. 21, p. 576-615.

The capillary rise of water and certain salt solutions ( $\text{NaCl}$ ,  $\text{KCl}$ ,  $\text{Na}_2\text{SO}_4$  and  $\text{K}_2\text{SO}_4$ ) in tubes of elliptical cross section of known dimensions is measured, and the capillary constants deduced therefrom. Two sets of empirical formulæ are established, which allow calculating the two principal constants of capillarity when the concentration of these solutions and the capillary constant of water are known. Volkmann's rule, as well as that of Rodenbeck (see Nos. 426 and 403), as to the surface tension of miscible non-contracting liquids are verified on mixtures of the above salt solutions.

- 449.** 1884. BUNSEN, R. Ueber die langsame Verdichtung der Kohlensäure an blanken Glasflächen und Kayser's Einwürfe dagegen. *Wied. Ann.*, Vol. 22, p. 145-152.

As to Kayser's explanation of the anomalous adsorption phenomena of  $\text{CO}_2$  on glass surfaces (see No. 447), Bunsen points out that in Kayser's apparatus, which had the supposed fault to a large degree, only one-tenth of the amount of carbonic acid had disappeared that was absorbed in Bunsen's previous experiments (see No. 430). By a new series of experiments, wherein greased fittings were excluded, Bunsen was able to verify all his former, though abnormal, observations. He then proposes to study the influence of the air adhering to the glass surface.

- 450.** 1884. QUET, M. Sur l'accord de l'expérience et de la théorie dans l'élévation de l'eau entre des plaques verticales parallèles et mouillées. *Comptes Rendus*, Vol. 90, p. 87.

On the basis of Gay Lussac's Constant of Capillarity (see No. 76), the author establishes formulæ for the capillary elevation of water between parallel vertical glass plates. Experimental measurements are then adduced to test the correctness of these formulæ.

- 451.** 1884. GARBE, P. Sur les relations électrocapillaires. *Comptes Rendus*, Vol. 99, p. 123.

According to this author, the capillary constant of mercury, in contact with another fluid, is a maximum when the electric difference of the meniscus is zero, and its value is generally independent of the sign of this difference (compare No. 343).

- 452.** 1884. KAYSER, H. Ueber die Verdichtung der Kohlensäure an Glasflächen und ihre Diffusion durch Fettschichten. *Wied. Ann.*, Vol. 23, p. 416-426.

Renewed experiments lead the author to reaffirm that adsorption is accomplished rapidly after introduction of the carbonic acid gas, if the glass was previously made gas-free. The adsorbed quantity increases with increasing pressure and decreases with increasing temperature (compare No. 430). The suggestion is offered that the slowness of adsorption in Bunsen's experiments may be due to a very gradual replacing of the occluded air by carbon dioxide gas.

- 453.** 1884. WORTHINGTON, A. M. On the Surface Forces in Fluids. *Phil. Mag.*, (5), Vol. 18, p. 334-364.

From consideration of the elastic and thermal properties of solids, liquids and gases, the author synthetically proceeds to prove a rapid variation of density at the surface of a liquid, which causes the existence of either a tension or a pressure in the surface of liquids, exerted at the line of contact with a solid. From this principle of surface tension or pressure, linked with the well-known laws of hydrostatics, all capillary phenomena, including the horizontal motion of floating bodies (see No. 482) can be easily deduced.

- 454.** 1885. DALE, R. S. Some Novel Phenomena of Chemical Action Attending the Efflux from a Capillary Tube. *Chem. News*, Vol. 51, p. 58-59.

A capillary siphon with its exit end bent upward transfers liquid A into liquid B, forming, when mixed, insoluble precipitates. Striking effects are thus obtained, consisting in the formation of solid tubes of precipitate, liquid A rising until it meets liquid B at the summit of the tube. Such pairs of liquids are, for example,  $\text{Na}_2\text{SO}_4$  and  $\text{BaCl}_2$ , or ammonium oxalate and calcium chloride, or ammonia water and ferrous sulphate, sodium carbonate and copper sulphate, etc.

- 455.** 1885. SCHALL, C. Attraction of Homogeneous Molecules. *Jour. Chem. Soc. Abst.*, 1885, p. 111-112, from *Ber. d. D. Chem. Ges.*, Vol. 17, p. 2555-2577.

The cohesion between the molecules of a liquid may be measured by means of adhesion plates (see No. 38). The author shows in what manner the weights necessary to detach the disk from the liquid surface at two different temperatures are a function of the two prevailing specific gravities. An analogous relation is established between the capillary heights of rise and the specific gravities at different temperatures. Water, benzene and its derivatives, form an exception to the first, and water and liquid sulphur to the second rule.

- 456.** 1885. VOLKMANN, PAUL. Bemerkungen zu der Arbeit des Hrn. R. Schiff (see No. 444). *Lieb. Annal.*, Vol. 228, p. 96-111 (1885).

Volkman recalculates Schiff's values, taking into account the existence of the edge angle formed by the meniscus, which was neglected by Schiff. On the whole, he agrees with the latter's conclusions.

- 457.** 1885. SCHIFF, ROBERT. Notiz zu Hrn. Paul Volkmann's Bemerkungen. *Lieb. Annal.*, Vol. 229 (1885), p. 199-203.

Volkman (see No. 456) having calculated the edge angle from Schiff's values for the meniscus heights, the latter states that, owing to evaporation of the liquid surfaces, the heights of the menisci, as observed by him, are unreliable quantities, and no reliable calculations can be based thereon. The author then reports new determinations of the constants of capillarity for benzol, furfural, etc., at their boiling points.

- 458.** 1885. GOLDSTEIN, M., and DAMSKI, A. Rise of Solutions in Capillary Tubes. *Jour. Chem. Soc. Abst.*, 1885, p. 115-116, from *Jour. Russ. Chem. Soc.*, Vol. 16, p. 642.

Valson's law (see No 311), according to which the capillary rise of salt solutions in one and the same tube is inversely proportional to the specific gravity, is shown to be non-existent for solutions stronger than 2 or 3-gramme molecules in one liter, and approximately correct only for weak salt solutions (0 to  $\frac{1}{8}$ -gramme molecule in 1 liter). A marked regularity exists between the capillary rise of equi-molecular solutions of KCl, KI and KBr; the capillary height of rise of KBr solutions, in one and the same tube, is the arithmetic means between that for KCl and KI solutions of equal concentration (compare No. 308).

- 459.** 1885. TRAUBE, J. Capillary Phenomena in Relation to Constitution and Molecular Weight. *Jour. Chem. Soc. Abst.*, 1885, p. 116-117, from *Ber. d. Deutsch. Chem. Ges.*, Vol. 17, (1885), p. 2294-2316.

The capillary rise of aqueous solutions of a great number of organic substances is measured. Voluminous tables are given, at once showing the difference in capillary height caused by difference in the concentration of solutions of the same substance, and comparing the capillary heights of unlike substances in solutions of the same degree of concentration. Among the more important conclusions are the following:

(1) The capillary height of the solution of an organic body decreases with increasing concentration, but not in linear measure.

(2) In a homologous series, the capillary height diminishes with increasing molecular weight.

(8) Isomeric substances in aqueous solution do not necessarily attain the same capillary height.

The capillary tube in one instance indicated the presence of formic acid, which was afterwards identified chemically; hence its possible use in chemical analysis (compare No. 272).

- 460.** 1885. LLOYD, JOHN URI. Separation by Capillary Attraction. *Jour. Chem. Soc. Abst.*, 1885, p. 477-478, from *Chem. News*, Vol. 51, p. 51-54, and *Proc. Amer. Pharm. Asso.*, 1884, p. 410-419.

The differentiating action of filtering paper upon solutions is shown by dipping strips of blotting paper into various solutions of inorganic and certain organic salts, and of acids in water, and observing the distance to which the dissolved substance travels before being left behind by the water which passes onward. From ferric sulphate solution, pure water could thus be abstracted by means of a paper siphon of sufficient height, while on the other hand sodium chloride traveled 6 feet with the water without showing signs of separation.

- 461.** 1885. SCHIFF, ROB. Constants of Capillarity of Liquids. *Jour. Chem. Soc. Abst.*, 1885, p. 717-721, from *Gazzetta chim. ital.*, Vol. 14, p. 368-447.

In a long series of determinations, the range of capillary equivalents (see No 444) is extended over bromine, iodine, sulphur and phosphorus, and some exceptions to the rule are recorded.

- 462.** 1885. BARTOLI, A. Capillary Constants of Liquids and Cohesion of Solids. *Jour. Chem. Soc. Abst.*, 1885, p. 866-867, from *Gazz. chim. ital.*, Vol. 14, p. 553-562.

The author announces the law that "specific cohesion" (see No. 463), divided by the product of specific heat and specific gravity, is a practically constant quantity for liquids containing C, H, O and S, but is slightly diminished when halogens are present. Another relation is established between atomic weight, coefficient of expansion, specific gravity and cohesion.

- 463.** 1885. TRAUBE, J. Capillary Constants of Certain Aqueous and Alcoholic Solutions. *Jour. Chem. Soc. Abst.*, 1885, p. 866, from *Jour. prakt. Chem.*, (2) Vol. 31, p. 177-219.

Continuation of former researches (see No. 459), among the results are the following:



The "specific cohesion" (height of rise in tube of 1 mm. radius) of mixtures of 2 liquids does not necessarily lie between the values shown by the component liquids, but may be lower than either. The cohesion of a saturated solution of an organic liquid (e. g., aniline) generally differs but slightly from that of the dissolved substance itself. Similarly, results are given for solutions of salts in water and dilute alcohol.

- 464.** 1885. TRAUBE, J. Influence of Temperature on the Capillary Meniscus Angle. *Jour. Chem. Soc. Abst.*, 1885, p. 1033, from *Jour. prakt. Chem.*, (2) Vol. 31, p. 514-527.

Upholds Schiff's results against Volkmann's criticism (see No. 456). From his own researches he finds that there exists for every liquid a temperature at which its capillary meniscus is hemispherical, but it gradually flattens with increase of temperature.

- 465.** 1885. SCHALL, C. Relation between Specific Gravity, Capillarity and Cohesion. *Jour. Chem. Soc. Abst.*, 1885, p. 1180, from *Ber. d. Deutsch. Chem. Ges.*, Vol. 18, p. 2032-2041.

The following laws are here restated (compare No. 455):

The capillary heights of rise ("specific cohesion"; see No. 466), or the weights necessary to detach adhesion plates from surfaces of the same fluid, decrease with increasing temperature in the proportion of the 8-3rd power of the prevailing specific gravities.

The corresponding surface tensions (see No. 444) decrease with increasing temperature in the proportion of the 11-3rd power of these specific gravities.

The laws are verified by making use of the values obtained by Schiff (see No. 444). Water forms an exception.

- 466.** 1885. SCHALL, C. Beziehungen zwischen den Capillaritäts Constanten der Glieder homologer Reihen in Bezug auf das Specifische Gewicht. *Ber. d. Deutsch. Chem. Ges.*, Vol. 18, p. 2042-2052.

The law previously announced (see No. 465) for one and the same liquid at different temperatures can be extended to include different liquids belonging to certain homologous series. Thus, with the first members of the benzene and the alcohol series, the capillary rise in tubes of 1 mm. radius (*specific cohesion*) at the boiling points of these liquids is in direct proportion to the 8-3rd power of their specific gravities at these temperatures. Other homologous series, e. g., those of the fatty acids or esters, do not follow the law. The exception is probably due to coalescence of molecules, which seems to be especially the case with formic and acetic acids.

- 467.** 1885. CHERVET, A. Note sur les constantes capillaires des solutions salines. *Comptes Rendus*, Vol. 101, p. 235.

Starting from the capillary constant and the inner cohesion of simple liquids, mathematical expressions are obtained for the mutual adhesion of immiscible, then miscible fluids, finally of solutions of salts in water.

- 468.** 1885. BEZOLD, W. VON. Ueber eine neue Art von Cohäsionsfiguren. *Wied. Ann.*, Vol. 24, p. 27-37 and 569-593.

A drop of aniline violet or another tinting fluid, placed upon the surface of water contained in a tumbler, instantly spreads over the surface, forming radial spokes; the excess sinks to the bottom, producing some striking figures within the body of the water. These figures are very sensitive to differences in temperature; for example, to the influence of a glass of ice water placed at a distance of several decimeters. If a high column of a solution is allowed to stand quietly for some time, slight differences in temperature will induce separate currents in the different layers, the motions of which are rendered visible by this method of producing cohesion figures (compare No. 256).

- 469.** 1885. BUNSEN, R. W. Ueber capillare Gasabsorption. *Wied. Ann.*, Vol. 24, p. 321-347.

A series of ingeniously conducted experiments lead the author to the following conclusions:

The cause of the absorption of  $\text{CO}_2$  by glass does not lie in the attraction of glass for this gas; glass entirely deprived of *moisture* absorbs no appreciable quantity of gas. But glass readily absorbs water and holds it tenaciously under an enormous capillary pressure at temperatures as high as  $470^\circ$ . This aqueous layer is the medium for the adsorption of  $\text{CO}_2$  by glass (compare Nos. 452 and 483).

- 470.** 1885. MAGIE, W. F. Ueber Capillaritäts-Constanten. *Wied. Ann.*, Vol. 25, p. 421-437.

A new method, suggested to the author by Prof. Helmholtz, for calculating surface tensions from a formula given by Poisson (see No. 117). It merely requires the measurement of the radius of curvature of the meniscus; if the latter is selected small enough to be hemispherical, the radius can be measured by applying the laws of mirror reflection. The author thus determined the surface tension of mercury, which he finds approximating the values of Desains (see No. 205) and others, although much lower than that found by Quincke (see No. 234; also see J. STÖCKLE, 1898). By the same method he determined the surface tension of alcohol, distilled water, chloroform, etc., comparing the results in tabulated form with those arrived at for the same liquids by Quincke (see No. 312).

- 471.** 1885. HEEN, P. DE. Premier Essai de Théorie des Liquides. *Ann. Chim. Phys.*, (6) Vol. 5 (1885), p. 83-120.

The gaseous, liquid and solid states of matter are characterized by *gazogenic*, *liquidogenic* and *solidogenic* molecules. For liquids a general relation is established between volume, temperature, coefficient of dilatation and molecular distance. The calculation of critical temperature, Gay Lussac's law of the dilatation of gases with temperature, and Mendeleef's law for fluids, are special cases of this general law. The hypothesis is advanced and verified that liquidogenic molecules attract each other in the inverse ratio of the 7th power of their distances (compare No. 408). Taking now into account the surface tension of liquids, relations are established between surface tension, temperature, and the coefficient of inner and of surface dilatation.

- 472.** 1885. WORTHINGTON, A. M. A Capillary Multiplier. *Phil. Mag.*, (5) Vol. 19, p. 43-46.

The lower surface of a platinum coil, the convolutions of which are kept about 2 mm. apart by interposed glass beads, forms an accurate plane. This instrument measures the surface tension of a liquid as follows:

It is suspended from one arm of a balance and tared; its lower horizontal surface is then allowed to touch the liquid, which at once rises to a definite height within the convolutions. The weight necessary to detach the instrument from the liquid, divided by the total length of the contact line of the meniscus, measures the surface tension (compare L. Wilhelm No. 273).

- 473.** 1885. WORTHINGTON, A. M. Note on a Point in the Theory of Pendent Drops. *Phil. Mag.*, (5) Vol. 19, p. 46-48.

The capillary constant (surface tension) of liquids may be calculated quite accurately by measuring certain elements of the contour of a drop pendent from a circular base. This the author has shown in a previous paper (*Proc. Roy. Soc.*, 1881, No. 214). A more favorable mode of measurement is now introduced, which simplifies the formula containing an expression for the surface tension.

- 474.** 1885. WORTHINGTON, A. M. On the Error Involved in Professor Quincke's Method of Calculating Surface Tensions from the Dimensions of Flat Drops and Bubbles. *Phil. Mag.*, (5) Vol. 20, p. 51-66.

Quincke's method of measuring the constant of capillarity (specific cohesion) by measuring the dimensions of flat drops or bubbles (see No. 304), gives results always higher than those from capillary tubes. The former method he believes to give the correct results, provided the drops or bubbles are selected sufficiently large that their top can be considered as flat and their extension as practically infinite. The author, however, shows that by not omitting the curvature on top of even large drops, and their finiteness, Quincke's results, recalculated, agree well with those from capillary tubes for the same substances; otherwise the discrepancy may reach 10 per cent.

- 475.** 1885. LUVINI. The Spheroidal State of Liquids. *Nature*, Vol. 32, p. 635.

In order to test the supposition that liquids in the spheroidal state (see No. 28) do not boil because they have lost their dissolved air, air was blown into the drop while being heated. Persistent bubbles, often larger than the liquid mass, arose, sharing the movements of the drop, but sometimes they moved independently. Such bubbles were obtainable with pure and soapy water, alcohol and ether. The inference is that liquids in that state do not appreciably lose their dissolved air.

- 476.** 1885. TAIT, P. G. *Properties of Matter*. Edinburgh, 1885.  
One chapter of this book is devoted to capillarity

- 477.** 1886. QUINCKE, G. Ueber die Bestimmung der Capillarität Constanten von Flüssigkeiten. *Wied. Ann.*, Vol. 27, p. 219-228.

The cause of the discrepancy between Quincke's capillary constants of mercury, water and salt solutions, and those of other observers, is due, according to Quincke, to the reality of an edge-angle, which was assumed to be zero by Volkmann, Worthington, Magie, etc. (see Nos. 410 and 470). For glass and water or aqueous salt solutions, the angle is from  $20^\circ$  to  $80^\circ$ .

- 478.** 1886. EÖTVÖS, R. Ueber den Zusammenhang der Oberflächen-spannung der Flüssigkeiten mit ihrem Molecular-Volumen. *Wied. Ann.*, Vol. 27, 448-459.

The author since 1875 has employed optical reflection from capillary surfaces for the determination of the constant of capillarity of liquids. The method is applicable even to liquids contained in sealed glass tubes; hence the method allows measurements at temperatures far above the boiling points of these liquids. A simple relation between molecular volume, temperature and surface tension is deduced and verified from data supplied by the author's method and Schiff's experiments (see No. 444).

- 479.** 1886. WEINSTEIN, B. Untersuchungen über Capillarität. *Wied. Ann.*, Vol. 27, p. 544-584.

Theoretical treatment of capillary constants by Gauss's method, based on the Young-Laplace theory (see Nos. 63 and 115).

- 480.** 1886. VOLKMANN, P. Notiz zu Hrn. G. Quincke's Bemerkungen "Ueber die Bestimmung der Capillarconstanten von Flüssigkeiten." *Wied. Ann.*, Vol. 28, p. 135-144.

Volkman insists on the fact that he has avoided finite edge angles in his researches by insuring perfect wetting of the solid by the liquid. He points out that on this account his results were uniform.

- 481.** 1886. NOACK, KARL. Ueber die Fluidität der absoluten und verdünnten Essigsäure. *Wied. Ann.*, Vol. 28, p. 666-684.

Continuation of a preceding paper on the influence of temperature and concentration upon the fluidity of liquid mixtures (*Wied. Ann.*, 1885, Vol. 27, p. 289-300). The author illustrates by diagrams the linear increase of fluidity with temperature for acetic acid of different concentrations, and shows decrease of fluidity with increasing concentration until a minimum is reached at 77% irrespective of temperature, this minimum corresponding to the formula  $C_2H_4O_2 + H_2O$  (compare Graham, No. 264). Further increase of concentration again increases fluidity.

- 482.** 1886. FUCHS, KARL. Ueber den Randwinkel einander berührenden Flüssigkeiten. *Wied. Ann.*, Vol. 29, p. 140-152.

For two liquids in mutual contact, several equations are established expressing relations between the work of surface alteration (work of cohesion and adhesion), tension of common surface and edge angle. The latter was recognized to be theoretically constant and independent of the radii of curvature of the liquids. It solely depends on the molecular forces existing in the two liquids.



- 483.** 1886. BUNSEN, R. Zersetzung des Glases durch Kohlensäure enthält viele capillare Wasserschichten. *Wied. Ann.*, Vol. 29, p. 161-165.

The glass threads used by the author in his absorption experiments (see No. 469) were found to be decomposed by  $\text{CO}_2$  to the extent of 5.83 %. Part of the  $\text{CO}_2$  formerly evolved upon warming was, no doubt, due to decomposition of bicarbonate formed, but an additional amount must have been due to other causes.

The author concludes that glass is not a proper material for the study of physical absorption of  $\text{CO}_2$ ; the employment of fine threads of platinum or gold is suggested.

- 484.** 1886. ROENTGEN, W. C., and SCHNEIDER, J. Ueber Compressibilität und Oberflächenspannung von Flüssigkeiten. *Wied. Ann.*, Vol. 29, p. 165-213.

The authors prepared aqueous solutions of iodides, bromides, chlorides, nitrates, hydroxides, sulphates and carbonates of hydrogen, ammonium, lithium, potassium and sodium of equimolecular strength. Then they determined the compressibilities and the surface tensions of these solutions. From the elaborate tables thus obtained, the following conclusion is drawn: Within each group (e. g.,  $\text{HNO}_3$ ,  $\text{HBr}$ ,  $\text{HOH}$ ,  $\text{H}_2\text{SO}_4$ , or  $\text{LiI}$ ,  $\text{LiNO}_3$ , etc.) the liquid with the smaller molecular compressibility has the greater surface tension.

- 485.** 1886. STEFAN, J. Relation between the Theories of Capillarity and Evaporation. *Jour. Chem. Soc. Abst.*, 1887, p. 323, from *Wied. Ann.*, Vol. 29, p. 655-665.

A relation is established between the latent heat of evaporation, the specific gravity of the liquid, and the difference of molecular pressure existing in the interior and the surface of the liquid. For ether, the author finds the enormous interior pressure of 2574 atmospheres, for  $\text{CS}_2$  he finds 2728 atmospheres. Sir W. Thomson's conclusions as to the connection between evaporation and curvature of evaporating surfaces (see No. 319) are herein confirmed.

- 486.** 1886. DUHEM, P. Application of Thermodynamics to Capillary Phenomena. *Phil. Mag.*, (5) Vol. 22, p. 230-231.

General equations are established on thermodynamical principles, which bring the theory of Thomson (see No. 319) into agreement with those of Laplace and Gauss (see Nos. 64 and 115). The equations are then applied to the two special processes of evaporation and supersaturation.

- 487.** 1886. THOMSON, SIR WILLIAM. Capillary Attraction. A Lecture before the Royal Institution. *Nature*, Vol. 34, p. 270-272, 290-294, 366-369.

Starts out by illustrating the immense force of cohesion between two plane water surfaces in immediate contact; capillary elevation is deduced therefrom on the principle of equal work performed. This leads to the demonstration of the principle of surface tension in simple liquids and the tension of the common surface of immiscible and miscible liquids. Finally, some experimental illustrations of capillary phenomena are given, e. g., the capillary behavior of mercury; the form and properties of drops, the displacement of a liquid of strong surface tension (water) by one of less surface tension (alcohol), for which the "tears of strong wine" are an example (see No. 213).

- 488.** 1886. MAGIE, W. F. Note on a Method of Measuring the Surface Tension of Liquids. *Amer. Jour. Science*, Vol. 131, p. 189-193.

The principle of the method by means of which the author proposed to decide the question of the existence of a contact angle is stated under No. 510. The results herein obtained still leave the question open.

- 489.** 1886. TRAUBE, J. Ueber die innere Reibungsconstante und die specifische Zähigkeit organischer Flüssigkeiten und ihrer wässrigen Lösungen. *Ber. d. Deutsch. Chem. Ges.*, Vol. 19, p. 871-892.

The apparatus employed by the author to determine the constant of the inner friction of liquids passing through capillary tubes, by Poiseuille-Hagenbach's method (see Nos. 162 and 246), also allows measurements of the weight of falling drops, therefore of capillary constants. The friction constants for a series of alcohols and of organic acids were determined at temperatures between 20° and 60°, and the results illustrated by diagrams in which were included the results of PAGLIANI and BATTELLI (Turin, 1885), for the same liquids at temperatures between 0° and 10° (compare No. 254). The volumes of the drops are proportional to the heights of rise of the liquids in capillary tubes. A further consequence is the rule that the dropping intervals are proportional to the products of friction constants and dropping volumes or capillary rise.

- 490.** 1886. TRAUBE, J. Methode zur Bestimmung des Fuselöls. *Ber. d. Deutsch. Chem. Ges.*, Vol. 19, p. 892-895.

Since aqueous solutions of high-molecular alcohols have a markedly lower capillary rise than corresponding solutions of ethyl alcohol, the presence of fusel oil in diluted spirits may be expected to be recognized by the decrease of capillary rise. The apparatus used by the author was previously described (*Journal f. prakt. Chem.*, 1886, p. 177). A table is given, showing the decrease of capillary rise of a 20% spirits containing fusel oil of varying percentages (0 to 1%) (compare No. 505).

- 491.** 1886. TRAUBE, J. Ueber die Grösse der Maximaltropfen der gewöhnlichen Alcohole und Fettsäuren, und ihrer wässrigen Lösungen. *Ber. d. Deutsch. Chem. Ges.*, Vol. 19, p. 1673-1679.

The law previously stated (see No. 489) that the volumes of drops issuing from the lower circular end of a capillary tube are in exact ratio to the capillary heights of rise, does not hold good for very large terminal surfaces of the tube, because the drop size for increasing surfaces attains a maximum. This maximal drop, in other words, is the drop falling from a large horizontal surface. It is a constant, varying only with the cohesion of the fluids. The weight of one drop was determined by counting the drops yielded by a known volume of fluid, and multiplying by the specific gravity. An elaborate table is given, showing the maximal-drop size for alcohols and fatty acids at different temperatures. It confirms the natural supposition that the maximal diameter of these drops increases with increasing cohesion.

- 492.** 1886. TRAUBE, J. Ueber die Abhängigkeit der Tropfengrösse von äusseren Einflüssen. *Ber. d. Deutsch. Chem. Ges.*, Vol. 19, p. 1679-1682.

The influence of various conditions upon the size of drops has been exhaustively treated by Guthrie (see No. 276), and is confirmed by the author, especially as to effect of curvature of wall and velocity of flow. Contrary to Guthrie, however, the author is unable to detect an appreciable influence of the material of the wall upon the size and weight of drops; the deviations observed come within the scope of errors of observation. The author finally reiterates a former statement, to the effect that the edge-angle of one and the same liquid against glass and metal is nearly the same, and different from zero.

- 493.** 1886. TRAUBE, J., and BODLÄNDER, G. Ueber die Unterscheidung von Eiweisskörpern, Leim und Peptonen durch Capillarität. *Ber. d. Deutsch. Chem. Ges.*, Vol. 19, p. 1871-1876.

Musculus (see No. 272) classes albumin among the capillary inactive substances, i. e., that do not appreciably reduce the capillary rise of water. This property of albumen of various sources is verified by the authors. Gelatine behaves similarly, but peptones, e. g., those contained in Liebig's extract of beef, are active to a remarkable degree. Their presence in aqueous solutions causes a marked decrease of their capillary rise, respectively decrease of the volume of drops issuing from a vertical capillary tube (see No. 491); in other words, an increase in the number of drops yielded by a given volume of peptonated solutions.

- 494.** 1886. REINOLD, A. W., and RUECKER, A. W. On the Relation between the Thickness and the Surface Tension of Liquid Films. *Phil. Trans.*, 1886, Vol. 177, p. 627-684.

Contrary to the conclusions of previous observers, the surface tension of a soap film remains constant regardless of its thickness, a fact established over a wide range of thicknesses (12 to 1350 micromillimeters). The cause of the sudden discontinuity of the black film (see No. 376) at its edge is still in doubt; its thickness varies only between narrow limits, 7 to 14 micromillimeters, which remains fairly constant soon after its formation. The boundary line of a black film becomes ill defined when an electric current of sufficient intensity is passed through it, but is restored upon cessation of the current.

- 495.** 1886. TRAUBE, J. Capillary Constants and Meniscus Angle. *Journ. Chem. Soc. Abst.*, 1887, p. 101, from *Journ. prakt. Chem.*, [2] Vol. 34, p. 292-311.

Values are obtained for the "specific cohesion" (theoretically the height of capillary rise in tubes of 1 mm. radius, the edge-angle being zero) for fatty alcohols and fatty acids at various degrees of concentration; both propyl and isopropyl alcohol show a minimum for mixtures of equal weights of the alcohol and water. Another series of determinations with the same fluids was made by measurements of falling drops of these fluids. The volume of the drops was found proportional to the capillary rise in one and the same tube; accordingly, the weight of the drops was found proportional to the product of the height and the specific gravity. The diameter of the tube determines the shape of the drop.

- 496.** 1886. TRAUBE, J. The Weight of Drops, and their Relation to the Constants of Capillarity and the Capillary Meniscus Angle. *Jour. Chem. Soc. Abst.*, 1887, p. 210-211, from *Jour. prakt. Chem.*, (2) Vol. 34, p. 515-538.

For water and solutions of alcohol of different strengths, the weights of drops and their capillary constants decrease with the increasing curvature of the surface of formation of the drops. This decrease, however, does not begin before a certain degree of curvature, which is different for different liquids, neither is this decrease proportional to the increase in curvature; it appears to be the greater, the smaller the capillary constant of the liquid. He also finds the edge angle of the meniscus of drops of different liquids to be equal or proportional to the meniscus angle of the same liquid in capillary tubes. Further properties of the meniscus of drops are developed.

- 497.** 1887. HELMHOLTZ, H. VON. A Cohesion Experiment. *Nature*, Vol. 35, p. 456.

If distilled water is placed above a mercury column in a barometric glass tube longer than 760 mm., the cohesion of the water will, provided that no vibrations occur, prevent the mercury column from falling to its barometric height, even if at the lower end a suction is applied down to 1 mm. vacuum. By means of this contrivance the minimum voltage necessary to electrolyse pure water was ascertained. This minimum occurred at 2.18 volts.

- 498.** 1887. DUFOUR, PROF. Surface Tension and Magnetism. *Nature*, June, 1887, p. 209.

The influence of a strong magnetic field upon the surface tension of mercury is shown. A jet of mercury issuing from a horizontal capillary tube describes a parabola, the vein being continuous to a certain distance. When allowing a strong electro-magnet to act on the jet, the parabola is stretched, and the continuous part of the vein lengthens.

- 499.** 1887. LENARD, PHILIPP. Ueber die Schwingungen fallender Tropfen. *Wied. Ann.*, Vol. 30, p. 209-243.

The surface tensions (see No. 444) of water, soap solution, alcohol and mercury, were deduced from measurements of the weights and the vibrations of falling drops of these liquids, observed by the method of intermittent photography. The surface tension of mercury was found to be 47.10 mg.-mm., for alcohol 2.50, for water from 7.25 to 7.34, these determinations being free from the assumption of an edge angle.



- 500.** 1887. TIMBERG, GUSTAF. Untersuchungen über den Einfluss der Temperatur auf die Capillaritätsconstanten einiger Flüssigkeiten. *Wied. Ann.*, Vol. 30, p. 545-561.

A review of the literature on the influence of temperature upon the constants of capillarity of liquids is given. New experiments are carried out by means of three different methods: viz., the measurement of flat air bubbles in various liquids, the method of adhesion rings and the measurement of the weight of drops (see Nos. 370 and 276). Tables are given, and the results illustrated by curves which nearly all are sloping straight lines. Ether is the liquid whose capillary constants change fastest with temperature; then follow benzol, alcohol, water and salt solutions.

- 501.** 1887. MELDE, F. Ueber einige Anwendungen enger Glasröhren. *Wied. Ann.*, Vol. 32, p. 659-670.

Describes a simple method for calibrating capillary tubes of 2-mm. inner width and downward. Shows how Boyle's law for gases can be demonstrated by means of a capillary tube closed at one end and containing a measurable volume of air separated from the outer air by a column of mercury. Measurements are taken with the tube first in the upright, and next in the inverted position. The same device can be used to calculate barometric pressure; hence it is called a *capillary barometer*. Finally, the author shows how capillary tubes can be used to measure the specific gravity of gases by measuring their different velocities (see No. 130).

- 502.** 1887. COLEMAN, J. J. On Liquid Diffusion. *Phil. Mag.*, (5) Vol. 23, p. 1-10.

Graham's experiments (see No. 253) on "jar diffusion" are herein extended over additional salt solutions. The diffusions were conducted in Mohr burettes; the diffusates, in due time, were drawn off fractionally and analyzed. Curves are given which illustrate the heights of diffusion for decreasing percentages. The march of diffusibilities for different salts is analogous to that of atomic and molecular volumes in Mendeleef's arrangement of elements.

- 503.** 1887. SUTHERLAND, W. On the Law of Molecular Force. *Phil. Mag.*, (5) Vol. 21, p. 113-114 and 168-187.

The author generalizes his previously announced molecular law for gases of the inverse 4th power as follows: Any two molecules of matter attract one another with a force proportional directly to the product of their masses, and inversely to the 4th power of the distance between them; the "molic" (astronomic) force acts in the inverse 2nd power. On this basis, the capillary theories of Laplace and Gauss are critically reviewed.

- 504.** 1887. SIEG, E. Ueber die Bestimmung von Capillaritätsconstanten an Tropfen und Blasen. *Dissert.*, 1887; also see *Nature*, Vol. 37 (1887), p. 167-168.

Quoted in detail by Lohnstein (see No. 552). The author critically reviews Quincke's measurements of capillary constants by the method of flat drops and bubbles, in order to account for the high results obtained by that method. He concludes that in Quincke's measurements the possible error of observation is quite large, and, additionally, the correction formula employed by Quincke is considered insufficient. In measurements of his own with air-free water by Quincke's method simplified, the author finds a lower value for the surface tension, more in accord with that of other observers except Quincke.

- 505.** 1888. ELSWORTHY, H. S. Note on a Modification of Traube's "Capillarimeter." *Jour. Chem. Soc. Trans.*, 1888, p. 102-104.

Traube's "capillarimeter," devised to detect the presence of fusel oil in distilled spirits (see *Zeitschrift f. Spiritusindustrie*, 1886, No. 36), is modified for the purpose of rendering the instrument more sensitive. This is done by fixing the capillary tube in an inclined position. A 20-% spirits (by volume) then rises to a length of 175 mm. against 50 mm. in Traube's instrument. The presence of 1-% fusel oil reduces this height by 25 mm. against 7 mm. in Traube's prototype. A drawback of the method is the probable necessity of reducing the spirit to 20 % by volume, which reduces still further an eventual low percentage of fusel oil.

- 506.** 1888. RUECKER, A. W. On the Range of Molecular Forces. *Jour. Chem. Soc. Trans.*, 1888, p. 222-262.

A full and interesting history of the researches on this subject, and a summary of results is recorded.

- 507.** 1888. GOLDSTEIN, M. Rise of Salt Solutions in Capillary Tubes. *Jour. Chem. Soc. Abst.*, 1889, p. 205, from *Jour. Russ. Chem. Soc.*, 1888, Vol. 20, p. 408-415.

An extension of former researches (see No. 458). With concentrated salt solutions of equal percentage, the solution of less molecular weight has the higher capillary rise. Inversely, with solutions of equal capillary height, the solution of less percentage has the higher molecular weight. The difference of capillary heights corresponding to a difference of percentage of salt solution becomes greater for the same difference of percentage of another salt of greater molecular weight.

- 508.** 1888. GOPPELSROEDER, F. On Capillary Analysis. *Phil. Mag.*, (5) Vol. 25, p. 244.

The basis of this method was laid by the researches of Schönbein; also see the author's former work (see Nos. 259 and 271). Coloring matters in not too concentrated solution may be differentiated by means of filtering paper; the zones, attained after a certain interval of time, are noted, and the zones separately extracted by suitable solvents. Each extract is then examined in a similar manner until zones of the pure coloring matters are obtained. Thus the author found picric acid in sophisticated beer, fuchsine in wine.

- 509.** 1888. BOYS, C. V. Experiments with Soap Bubbles. *Phil. Mag.*, (5) Vol. 25, p. 409-419.

Two soap bubbles may be pressed together, or even roughly knocked together, without bursting, owing to a film of air between them which they are unable to exclude. Increased pressure, however, destroys the bubbles. The existence of this air film is demonstrated by a series of beautiful lecture experiments on soap bubbles.

- 510.** 1888. MAGIE, W. F. On the Contact Angle between Liquids and Solids. *Phil. Mag.*, (5), Vol. 26, p. 162-183.

In order to decide the much-debated question of the existence of an edge-angle (see Nos. 477 and 480), the author determines  $\alpha^2$ , the "specific cohesion" for several liquids each by two different methods, both based upon measuring certain dimensions of air bubbles in these liquids under a horizontal glass plate (see No. 312). One of these methods is independent of the assumption of an edge angle; the other takes the edge angle into account; if this angle is really zero, both values ought to be identical. The author finds the angle zero for methyl and ethyl alcohol, formic acid, chloroform and benzine, the close agreement thus showing the usefulness of the method. The angle is finite for water (though small), for acetic acid ( $20^\circ$ ), turpentine ( $17^\circ$ ), petroleum ( $26^\circ$ ) and ether ( $16^\circ$ ). The author conjectures as to the cause of this contact angle.

- 511.** 1888. VAUTIER, TH. Recherches expérimentales sur la vitesse d'écoulement des liquides par un orifice à mince paroi. *Ann. Chim. Phys.*, (6) Vol. 15, p. 289-375 and p. 433-497.

The first of these two elaborate papers proves that Torricelli's law for the velocity of flow of liquids through an orifice at the bottom of the containing vessel holds good also for low pressures and narrow orifices, a case for which the law hitherto had not been tested. The author employs two different methods of measuring the velocity of a jet of water—one an optical, the other a photographic method, both of which are described in minute detail. Furthermore, Poiseuille's law of the inner friction of fluids passing through capillary tubes, is verified (see No. 162). The second paper deals with the application of the photographic method to the study of the flow of *viscous* liquids through capillary tubes.

- 512.** 1888. QUINCKE, G. Ueber die physikalischen Eigenschaften dünner fester Lamellen. *Wied. Ann.*, Vol. 35, p. 561-580; also see *Phil. Mag.*, Vol. 27 (1889), p. 79-80.

The surface of contact between liquids and thin solid films seeks to be a minimum, as is the case between two liquids or liquid and gas; only in the latter cases, spheres or bubbles result, while in the former case the thin solid forms plaited films, sometimes cylindrical surfaces, owing to the inability of the solid to contract laterally. Such solid laminae were obtained by allowing albumen, or aqueous solutions of glue, etc., to dry on mercury which was previously covered with a trace of fat. The periphery of the dried film is vertically wavy and connects with the center by radial ridges. Such solid films of isinglass, gelatin and agar-agar show double refraction of light. Other interesting properties are recorded.

- 513.** 1888. QUINCKE, G. Ueber periodische Ausbreitung an Flüssigkeitsoberflächen und dadurch hervorgerufene Bewegungserscheinungen. *Wied. Ann.*, Vol. 35, p. 580-642.

The expansion of a liquid 3 over the common surface of liquids 2 and 1 depends on the relative magnitude of the constants of capillarity (surface tensions) of their common surfaces. If the surface tension between 1 and 2 exceeds the sum of the tensions 1, 3 and 2, 3, the excess of this tension 1, 2 draws fluid 3 over the common surface 1, 2. On this principle the author discusses the formation and the stability of emulsions and foam, and the expansion of soap solutions, etc., at the common surface of oil and water, or the formation of a mercurial emulsion by shaking together mercury, water and olive oil. Other interesting topics herein considered are: The periodical expansion of oil and water; the periodic motions of resinous bodies precipitating from alcoholic solutions, and motion phenomena of physiological nature, e. g., protoplasmic motion, the formation of solid albumen at the common surface of fatty oils and water, etc.

- 514.** 1889. MARKOWNIKOFF. On a Method of Avoiding "Bumping" in Distillation. *Amer. Jour. Science*, Vol. 137, p. 222, from *Jour. Chem. Soc. Russ.*, 1887, p. 520, and *J. Chem. Soc. Abst.*, 1888, p. 1155.

Thin capillary glass tubes, 3 to 10 mm. in length, sealed at one end, are thrown into the liquid to be boiled. "Bumping" is effectively avoided, even with NaOH solutions and with concentrated acids, or in the presence of finely divided heavy precipitates such as BaSO<sub>4</sub>.

- 515.** 1889. SUTHERLAND, W. On the Law of Molecular Force. *Phil. Mag.*, (5) Vol. 27, p. 305-321.

The law of Eötvös (see No. 478) is stated as follows: "The rate of variation with temperature of the product of surface tension and the two-thirds power [the surface] of the molecular domain is the same for nearly all liquids." To this law, and Schiff's discovery of capillary molecular equivalents (see No. 444), the author applies his own hypothesis of the inverse 4th power of molecular force (see No. 503), and arrives at interesting results, for which see the original.

- 516.** 1889. MENSBRUGGHE, VAN DER. Sur les propriétés physiques de la couche superficielle libre d'un liquide et de la couche de contact d'un liquide et d'un solide. 2nd part. *Comptes Rendus*, Vol. 109, p. 607.

In conformity with Gauss's theory (see No. 115), the author advocates the existence of an extending, not contractile, force as accepted by Quincke (see No. 512) at the common surface of solids and wetting liquids. He gives simple examples to uphold his views (continuation of No. 365).

- 517.** 1889. KRAUSE, H. Ueber Adsorption und Condensation von Kohlensäure an blanken Glasflächen. *Wied. Ann.*, Vol. 36, p. 923-936.

In the absence of moisture, no condensation of CO<sub>2</sub> on glass takes place, whether the latter contains free alkali or not. The admission of moisture to the surface of perfectly dried glass threads is followed immediately by rapid condensation of CO<sub>2</sub>; more of the latter condenses on glass richer in alkali than on glass containing less or none. The glass threads containing more alkali retain water more tenaciously at higher temperatures than threads that have previously been boiled out with water (compare No. 493).



- 518.** 1889. THOMSON, SIR WILLIAM. *Popular Lectures and Addresses*. In 3 volumes. Vol. I. London, 1889.

Among the topics considered in this volume are: Constitution of Matter: Capillary Attraction, 1886; the Size of Atoms, 1883, etc.

- 519.** 1890. GOSSART, E. *Mesure des tensions superficielles dans les liquides en caléfaction (Méthode des larges gouttes)*. *Ann. Chim. Phys.*, (6) Vol. 19, p. 173-235.

The spheroidal state of liquids (*liquides en caléfaction*) is a particular case of capillary phenomena. The form and dimensions of the drop on the hot plate are determined by the surface tension along the liquid membrane enveloping the drop and the specific gravity of the inner liquid. The surface tension of liquids near their boiling points may thus be determined by measuring the greatest thickness of large elongated drops. Including examinations by other observers, the results of 50 liquids are tabulated. From the thickness of the drops, the surface tension of liquids near their boiling points is calculated, and the coefficients of average decrease of surface tension with temperature is deduced. Incidentally it was observed that the first five alcohols have at all temperatures about the same surface tension; the same is the case with the ethyl esters of the fatty acids.

- 520.** 1890. GOLDSTEIN, M. Rise of Solutions in Capillary Tubes and the general law of this phenomenon. *Jour. Chem. Soc. Abst.*, 1890, p. 684. From *Zeitschr. phys. Chem.*, Vol. 5, p. 233-241. Also see *Amer. Jour. Science*, Vol. 141 (1891), p. 64-65.

A distinct relation exists between the molecular mass of dissolved salts and the capillary height of rise of the solution. (See No. 507.) The author finds the laws of capillary rise to be analogous to that of vapor pressures, and a formula is given connecting the height of rise of water, of salt solution, molecular weight and percentage of solution. The law is extended so as to include Van't Hoff's coefficient  $i$  for electrolytes, uniform results being obtained.

- 521.** 1890. RAYLEIGH, LORD. On the Tension of Recently Formed Liquid Surfaces. *Nature*, Vol. 41, p. 566-568.

The author supports Marangoni's conclusions (see No. 326) that the surface tensions of soap solutions as determined by capillary tubes are independent of the strength, and that the difference in the surface tension of vertical soap films at different levels is due to the existence of a surface pellicle of lower surface tension. The author shows that when measured by means of the author's quick method of jets (see No. 402) the surface tensions of water and solutions of oleate of soda of varying strength are not reduced, while the slower method of capillary rise at once shows decrease of rise to one-third when passing from water to oleate solutions of different strengths.

- 522.** 1890. MAXWELL, JAMES CLERK. *The Scientific Papers of J. C. M.*, by W. D. Niven, 2 Vols. Cambridge, 1890.

In Vol. II., p. 541-591, is contained reprint of article in *Encyclopedia Britannica*. (See No. 374.)

- 523.** 1890. RAYLEIGH, LORD. On the Theory of Surface Forces. *Phil. Mag.* (5), Vol. 30, p. 284-298 and 456-475.

Discussing the theories of Laplace, Thomas Young and Gauss (see Nos. 63, 64, 115), the author upholds the view of an enormous molecular or "intrinsic" pressure in liquids (Laplace's Constant  $K$ .) It is probably analogous to the force necessary to break a solid. Young calculated it to be about 23,000 atmospheres (compare No. 415.) Berthelot (1850) showed that water was capable of sustaining a tension of 50 atmospheres. Theoretical calculations of the inner pressure of fluid masses are given, and different capillary problems are discussed, e. g., the tension of the common surface of liquids, the edge angle, etc. The author points out the generally unknown fact that Thomas Young (*Works*, Vol. I, pp. 461) has already estimated the limits of cohesion and the range of molecular forces.

- 524.** 1890. RAYLEIGH, LORD. On the Tension of Water Surfaces, Clean, and Contaminated, Investigated by the Method of Ripples. *Phil. Mag.* (5), Vol. 30, p. 386-400.

The object of this paper was to determine the ratio of surface tensions between pure water and a water surface contaminated with fat to just that degree where motions of camphor on its surface are no longer visible. The method is that of measuring the wave-length of ripples. (See No. 527.) The surface tension of water contaminated to the point stated was 72% of that of pure water. The same surface tension is found for water saturated with camphor; if saturated with olive oil, the tension is 54%; with sodium oleate, 34%.

- 525.** 1890. BECHHOLD, J. Chemical Energy at the Surface of Liquids. *Jour. Chem. Soc. Abst.*, 1890, p. 328; from *Zschr. phys. Chem.*, Vol. 5, p. 68.

The observation of W. Spring (*Zschr. phys. Chem.*, Vol. 4, pp. 658-662), to the effect that a prism of calc spar dipping to half its length into dilute hydrochloric acid is cut in two by the solvent action at the surface of the acid, is shown by the author not to be due to a specific surface action of the liquid, as was supposed by Spring; since the same phenomenon takes place when the upper half of the crystal is coated with wax and nearly the whole crystal immersed into the liquid.

- 526.** 1890. RAYLEIGH, LORD. On the Superficial Viscosity of Water. *Nature*, Vol. 42, p. 282-287.

The author confirms Plateau's observation (compare No. 412), that the surface viscosity of ordinary water is nearly twice as great as the interior viscosity, but proves that this is due to contamination of the water surface. If a gentle stream of air be directed vertically downward upon a water surface dusted over with fine powder, a clear circle is formed around the point of impact. On the cessation of the current the dust returns. The purified surface showed a slightly less viscosity than the interior. The question arises: To what thickness must the original film be concentrated to check the motions of camphor on water? (Compare Nos. 40 and 524.)

- 527.** 1890. SMITH, MICHIE. Determination of the Surface Tension of Mercury by the Method of Ripples. *Nature*, Vol. 44, p. 575;

Ripples are generated on the mercurial surface by means of a tuning fork (see No. 664), and the surface is photographed along with a suitable scale. The lengths of the ripples can thus be conveniently measured. The results are concordant and agree with the mean value of Quincke. A few measurements of the surface tension of water also give concordant results.

- 528.** 1890. BOYS, C. V. *Lectures on Soap Bubbles*, London, 1890. German Translation, by G. Meyer, Leipzig, 1893.

- 529.** 1890. PASCHEN, F. Zur Abhängigkeit der Oberflächenspannung an der Trennungsfläche zwischen Quecksilber und verschiedenen Electrolyten von der Polarisation. *Wied. Ann.*, 1890, Vol. 39, p. 43-66.

Lippmann's curve of surface tensions of dilute sulphuric acid with electromotive forces as abscissae have a maximum (see No. 343); the accuracy of this curve as far as the maximum is verified by the author. Beyond that his curve deviated from that of Lippmann, the cause being seen in the disturbing evolution of hydrogen. A new and sensitive electrometer is constructed which avoids this influence, and tables are obtained and curves are plotted showing the march of surface tensions with electromotive force for mercury against dilute sulphuric acid, hydrochloric acid and salt solutions.

- 530.** 1890. PASCHEN, F. Zur Oberflächenspannung des Polarisirten Quecksilbers. *Wied. Ann.*, Vol. 40, p. 36-52.

In continuation of his previous work (see No. 529) the author finds that the curve expressing relation between surface tensions and electromotive forces beyond the maximum depends on the concentration of the solution in contact with the mercury. Furthermore, the author investigates a possible connection between the curve maximum and the beginning of electrolysis.

- 531.** 1890. SOHNCKE, L. Die schliessliche Dicke eines auf Wasser sich ausbreitenden Oeltropfens. *Wied. Ann.*, Vol. 40, p. 345-355.

A known small quantity of olive oil or rape oil is deposited on a comparatively large water surface. It spreads out in a thin disk which soon simultaneously on all parts of the disk resolves itself into small drops. The thickness of the film immediately after its formation can be readily calculated from its diameter, its weight and specific gravity by a simple geometrical proposition. The author finds the thickness for olive oil to be about 111 micromillimeters; for rape oil about 94.

- 532.** 1890. RÖNTGEN, W. C. Ueber die Dicke von cohärenten Oelschichten auf der Oberfläche des Wassers. *Wied. Ann.*, Vol. 41, p. 321-329.

If ether vapor falls through a funnel against the center of a circular water surface, a central cavity is formed, surrounded by a zone of elevated waves. If the surface is touched by a trace of fat, the cavity remains, but the waves are replaced by a sharply defined circle of definite diameter, contending against a concentric fatty layer. The diameter of the inner circle depends on the quantity of fat employed. If the funnel is removed the circle readily contracts.

- 533.** 1890. CHRISTIANSEN, C. Die atmolytische Strömung der Gase. *Wied. Ann.* Vol. 41, p. 565-587.

The author defines the phenomena of Effusion, Transpiration and Diffusion of gases. Instead of the usual method of employing capillary tubes, the author uses parallel glass plates carefully ground upon each other to study the phenomena of transpiration and atmolysis of gases discovered by Graham (see No. 269). Atmoly-sis (separation of mixtures of gases) takes place at plate distances much smaller than the wave length of light while transpiration (involving friction) takes place at greater distances.

- 534.** 1890. WIEDEBURG, O. Ueber die Hydrodiffusion. *Wied. Ann.* Vol. 41, p. 675-711.

A good summary of the mathematical and experimental treatment of diffusion is given. The present paper consists in a generalization of Fick's law (see No. 214) mathematically considered and examined experimentally by the same arrangement as that employed by Wroblewski (see No. 418).

- 535.** 1891. SELBY, A. L. On the Variation of Surface Tension with Temperature. *Phil. Mag.* (5). Vol. 31, p. 430-433.

By mathematical reasoning the author concludes that Mendeleeff's rule concerning the variation of surface tension of liquids with temperature, is correct. By means of Mendeleeff's formula, the critical temperature of a liquid can be calculated by determining the surface tension at two widely different temperatures.

- 536.** 1891. GOSSART EMILE. Remarques expérimentales sur une catégorie de phénomènes capillaires, avec application à l'analyse des liquides alcooliques et autres. *Comptes Rendus*, Vol. 113, p. 537. *Ann. Chim. Phys.* (7) Vol. 4 (1895), p. 391-423: Caléfaction et Capillarité.

In his studies of Leidenfrost's phenomenon (see No. 519), the author was led to determine by means of a sensitive pyrometer, the minimum temperatures possible for spheroidal drops to exist on heated plates. On well-polished plates of silver or gold, a spheroid of water may be maintained at even 80° C. This suggests



that the spheroidal state may possibly be realized in the cold, which is confirmed by several experiments. Under this category comes the rolling of drops upon liquids of their own substance. This being due to a thin layer of vapor, sulphuric acid rolls better at  $100^{\circ}$  C. than at ordinary temperature, while ether rolls better at  $0^{\circ}$  C. than at  $20^{\circ}$  C. The drops of one liquid never roll upon another different liquid with which it is miscible, unless the latter liquid contains some of the former as an impurity. On this observation is based an even approximately quantitative method of analysis of alcoholic liquors.

- 537.** 1891. TRAUBE, J. Ueber die Capillaritätsconstanten von Salzen bei ihrem Schmelzpunkte. *Ber. d. Deutsch. chem. Ges.* Vol. 24, p. 3074-3080. Also see *Jour. Chem. Soc. Abst.* 1892, p. 7.

For salts, a new capillary constant is established by determining the weights of drops of salts at their melting points, and dividing this value by the weight of an equal number of drops of water from the same apparatus. The tabulated results show certain regularities. Thus the new constants for potassium salts of monobasic acids lie between 112 and 157, of bibasic and polybasic acids between 168-231. The limits for the corresponding sodium-salts are 123 to 161 and 189 to 325, a bibasic acid can thus be distinguished from a monobasic acid. For example, with potassium fluoride, the results point to the formula  $K_2 F_2$ .

- 538.** 1891. POCKELS, AGNES. Surface Tension. A letter communicated by Lord Rayleigh. *Nature.* Vol. 43, p. 437-439.

The surface tension of pure and impure water is measured by means of a rectangular tin trough, 70 cm. long, 5 cm. wide, 2 cm. high, filled with water to the brim. A strip of tin, about  $1\frac{1}{2}$  cm. wide being laid across it, divides the surface into two parts. By shifting this partition, the surface on either side can be lengthened or shortened in any proportion. The surface tension in either part of the trough was measured by the weight necessary to detach from the surface a small disk, 6 mm. in diameter. A series of systematic experiments was carried out by means of this simple apparatus (Compare No. 562).

- 539.** 1891. BESSEY, CHARLES E. and WOODS, ALBERT F. Transpiration, or the Loss of Water from Plants. *Proc. A. A. S.* 1891, p. 305-308.

Among numerous references to literature on this subject, a more recent and meritorious work by ALFRED BURGERSTEIN is quoted entitled: *Materialien zu einer Monographie, betreffend die Erscheinung der Transpiration der Pflanzen.* 2 Vols. 1887 and 1889.

- 540.** 1861. BEAL, W. J. Movements of Fluids in Plants. *Proc. A. A. S.* 1891, p. 309-313.

The subject is considered from two points: Ascertaining the channels which fluids take in plants, and the causes of their motion. Detailed reference is made to a recent work by MARSHALL WARD entitled: *Timber, and some of its Diseases.*

- 541.** 1891. GARDINER, WALTER. Flow of Water in Plants. *Nature.* Vol. 44, p. 189.

The author demonstrates the existence of upward root pressure in plants, the transpiration current due to evaporation on leaves, and determines the amount of water absorbed by the root by simple measurements.

- 542.** 1891. TRUSSEWITSCH, A. A. Surface Tension of the Halogens. *Journ. Chem. Soc. Abst.* 1891, p. 257. From *Zeitschr. Phys. Chem.* Vol. 6, p. 360.

This preliminary communication, gives the results of measurements of the capillary elevation of bromine and liquid chlorine.

- 543.** 1891. RAMSAY, WILLIAM. The Surface Tension of Ether and Alcohol at Different Temperatures. *Reports Brit. Assoc. Adv. Sc.* 1891, p. 565-566.

The surface tension of alcohol and ether determined by means of capillary tubes, is not a linear function of temperature, the measurements being made between the ordinary and somewhat below the critical temperatures. The angle of contact for ether is  $90^\circ$  at the critical temperature, and becomes zero at  $160^\circ$  C. Below this temperature, the angle of contact has a finite small value.

- 544.** 1891. RAMSAY, W. Surface tension of Water. *Zeitschr. phys. Chem.* Vol. 12, p. 471.  
Referred to by SIEDENTOPF, 1898.

- 545.** 1891. SENTIS, H. Method of Determining the Surface Tension of Mercury. *Phil. Mag*, (5). Vol. 32, p. 564; from *Jour. de Physique*, Vol. IX (1890), p. 384.

The surface tension of mercury is determined by allowing a rectangular plate of iron of known dimensions to float on mercury. By applying the principle of Archimedes on the one hand, and expressing the connection between capillary depression and surface tension on the other, two equations are obtained from which the surface tension independent of the edge angle may be calculated. The value found for mercury was 39.23 mg per mm.

- 546.** 1891. MENSBRUGGHE, VAN DER. On the Condensation of Aqueous Vapor in Capillary Spaces. *Phil. Mag* (5), Vol. 31, p. 74; from *Beibl. d. Physik*, Vol. 11 (1890), and *Bull. Ac. Belg.* (3), Vol. 19 (1890), p. 101.

The author endeavors to give experimental proof of Thomson's theory (see No. 319). Examples are given of the condensation of vapors in capillary spaces, e. g. the deposition of ice flowers on the dusty part of window panes; the increased rusting of iron where it is apparently protected by cloth, dry wood, etc., the fog-producing action of dust, etc. The durability of the clothing with which Egyptian mummies are covered, depends on the filling of the capillary spaces with wax. Oil-paintings should be varnished on the back to preserve them.

- 547.** 1891. TRAUBE, J. Capillary Constants of Organic Substances in Aqueous Solutions. *Lieb. Ann.*, Vol. 265, p. 27-55. Also see *Jour. Chem. Soc. Abst.*, 1891, p. 1408-1411.

The excess of the capillary constants of water over the corresponding constants of aqueous solutions of organic bodies, in more or less dilute solution is proportional to the concentration; in other words, the product of the concentration (expressed in molecular terms) and either of the two principal constants of capillarity (*specific cohesion* and *surface tension*, see Nos. 466 and 444) is a constant quantity in dilute solution. In the case of salts it approximates the value *one* at all concentrations (see Nos. 453 and 427). This product the author calls respectively *specific molecular cohesion* and *real molecular cohesion* (compare CARL FORCH, 1899). Elaborate tables are given for organic acids, alcohols and esters, etc., wherein these constants are recorded for various concentrations. In stronger solutions, constancy of these values is no longer maintained, and the author believes that conclusions may be drawn therefrom as to coalescence of molecules into larger groups. Some marked regularities were observed, for which see the original.

- 548.** 1891. COLSON, ALBERT. Sur l'écoulement des liquides en tubes capillaires. *Comptes rendus*, Vol. 113, p. 740.

Owing to the indisputable influence of temperature upon the velocity of flow of liquids, especially viscous ones, through capillary tubes, the author determined in a specially devised apparatus the time of flow of 5 cc. of liquids at their boiling points. For perfectly mobile liquids, e. g. ether, aldehyde, chloroform, water, mercury, etc., the law analogous to that of Graham for gases (see No. 130) was found: The time of flow of liquids at their boiling point is proportional to the square root of their densities.

- 549.** 1891. DRUDE, P. Ueber die Grösse der Wirkungssphäre der Molecularkräfte und die Constitution von Lamellen der Plateau'schen Glycerin-Seifen-Lösung. *Wied. Ann.* Vol. 43, p. 158-176.

The results of previous determinations of the diameter of the sphere of molecular action are here recorded. The author finds the thickness of the black film in soap bubbles to be constant, and equal to 17 micromillimeters, hence the thickness of the sphere of molecular action 8.5 micromillimeters. (Compare No. 553.)

- 550.** 1891. KAYSER, H. Ueber Diffusion und Absorption durch Kautschuk. *Wied. Ann.* Vol. 43, p. 544-553.

In the phenomenon of diffusion of gases through Caoutchouc, the same law prevails for the quantity diffused, as in the diffusion of ammonia gas through water (see No. 551) and an equation is given expressing this law. The author confirms the observation of Wroblewski that for several gases the quantity absorbed by Caoutchouc, is in proportion to the pressure (*Henry's law*). For  $\text{CO}_2$  and Hydrogen, the velocity of the gas passing through Caoutchouc is proportional to the temperature, which is the reverse of the diffusion of these gases through liquids. (Also see No 369).

- 551.** 1891. MUELLER, JOHANNES. Ueber die Diffusion des Ammoniaks durch Wasser und durch Alcohol. *Wied. Ann.* Vol. 43, p. 554-567.

The Diffusion constant for a stated temperature is here defined as the quantity of Ammonia passing in one minute through a column of water or alcohol, 1 cm. long and 1 cm. square cross section at a difference of pressure of 1 cm. The ammonia is allowed to touch one end of a horizontal column of water or alcohol, the other end being in contact with air. After a stationary condition of absorption has taken place, the diffusing quantity is in proportion to the cross section, and in inverse proportion to the length of the tube. The Diffusion constants for alcohol and water at one and the same temperature seem to stand in the same relation as the respective absorption coefficients at these temperatures.

- 552.** 1891. LOHNSTEIN, TH. Ueber den Einfluss der Capillarität auf die Gleichgewichtsverhältnisse schwimmender Körper. *Wied. Ann.* Vol. 44, p. 52-73.

Mathematical development of formulæ expressing the molecular equilibrium of drops and concave fluid surfaces; verified by measuring the volume of meniscus from its height and diameter in especially constructed cylindrical containers.

Wilhelmy's abnormal results, although wrongly interpreted by him (see No 273 and 279), and certain irregular results of Quincke lead the author to correct the usually accepted capillary theory of Gauss and Kirchhoff (see No. 115 and Kirchhoff, *Mechanik* § 5, p. 147) by taking into numerical account the surface of contact between the solid and the liquid. On the basis of this theory, a formula is derived for the equilibrium of floating bodies and verified from measurements on floating bodies of especial construction.

- 553.** 1891. REINOLD, A. W. and RUECKER, A. W. Ueber den Radius der Wirkungssphäre der Molecularkräfte. *Wied. Ann.* Vol. 44, p. 778-783.

While agreeing in the main with Drude's numerical result regarding the thickness of the black spot in soap films, the authors object to his assertion that this thickness is equal to twice the radius of the molecular sphere of action. They hold that this sphere of action has a considerably greater radius.

- 554.** 1892. SHENSTONE, W. A. Note on the adhesion of mercury to glass in the presence of Halogens. *Jour. Chem. Soc. Trans.* 1892 p. 452-453.



In the presence of chlorine, mercury acquires the power of adhering to glass in a remarkable degree. If chlorine is delivered into a tube filled with mercury, the tube is entirely coated with the metal. This phenomenon masks the rise and fall of mercury in pressure gauges, if chlorine is present. Bromine acts similarly, as does iodine, but to a less marked degree. These phenomena are transitory, owing to subsequent chemical combination.

- 555.** 1892. WEINBERG, B. [Surface Tension and Temperature.] *Jour. de Physique*, 1892 p. 378; also see *Wied. Ann. Beiblätter* Vol. XVI p. 496. (1892).

The paper is referred to by T. P. Hall (see No. 573). The author finds for the surface tension of water the expression:  $80.1 - .177t$  in dynes.

- 556.** 1892. WHITMORE, JOHN. A Method of Increasing the Range of the Capillary Electrometer. *Amer. Jour. Science*, Vol. 144, p. 64-70.

The capillary electrometer of Lippmann (see No. 343) only allows measurements of low potential differences, not higher than about 0.5 volt, owing to disturbances by polarization at higher potentials. A new capillary electrometer was constructed by the author, based on the principle that when a capillary tube is filled with alternating globules of mercury and dilute sulphuric acid, the difference of potential which can be maintained between the extremities of the series, increases proportionally with the number of globules of mercury. Each globule of mercury in contact with sulphuric acid represents a cell in the author's "series electrometer." The interposition of uniform successive cells is accompanied by an even fall in potential. Measurements of voltage of different battery cells by this method agree well with parallel measurements by means of Thomson's electric balance.

- 557.** 1882. RAYLEIGH, LORD. On the Theory of Surface Forces. II. Compressible Fluids. *Phil. Mag.* (5) Vol. 33, p. 209-220.

An extension of the former paper, (see No. 523) to include the property of compressibility in liquids. Largely theoretical considerations concerning the constitution of the interior and the surface of fluids and their connection with vapor pressure.

- 558.** 1892. RAYLEIGH, LORD. Experiments upon Surface Films. *Phil. Mag.* (5) Vol. 33, p. 363-373.

Miscellaneous interesting capillary phenomena are discussed, e. g. the spreading of water or olive oil on clean mercury, the former spreading slowly, the latter flash-like; camphor movements as a test of surface tension (see No. 524), the influence of heat upon a water surface sprinkled with lycopodium or sulphur, etc. If the interior of a saponine bubble is united with that of a soap bubble, the latter, having the smaller surface tension, increases, the other contracts, and becomes characteristically wrinkled. Finally the author speaks of Breath figures and their screen projection.

- 559.** 1892. MIALL, L. C. The Surface Film of Water and its relation to the Life of Plants and Animals. *Nature*, Vol. 46, p. 7-11.

The resistance which the surface film of water offers to the passage of a solid, especially of gauze through its surface, and the tenacity with which the surface film clings to solids, especially when in the form of fine meshes (e. g. a dry muslin bag), and similar capillary phenomena are demonstrated. They explain why certain aquatic plants and animals e. g. *Salvinia aquatica*; Duckweed (*Lemna minor*); the water spider (*Argyroneta aquatica*) etc., manage to keep dry. The account of the manner in which the water spider obtains its air supply from the surface and fastens the bubble securely under water, is extremely interesting,

- 560.** 1892. BARKER, G. F. *Physics*. 3rd Ed. New York. Treats of Capillarity, p. 200 & ff.

- 561.** 1893. SUTHERLAND, W. The laws of Molecular Force. *Phil. Mag.* (5) Vol. 35, p. 211-295.

An important paper, making detailed reference to surface tension. Compare No. 563 and *ibid.*, Vol. 36, p. 150.

- 562.** 1892. POCKELS, A. On the Relative Contamination of the Water Surface by Equal Quantities of Different Substances. *Nature*, Vol. 46, p. 418-419.

Lord Rayleigh's criterion of a definite degree of impurity of a water surface consists in observing the point where the motions of camphor on water cease (see No. 524). The author proposes another criterion which while indicating a smaller degree of contamination, is always fixable with great exactness, viz. that degree at which the surface tension of pure water just begins to sink, as shown by the author's method (see No. 538). A table is given, showing how much of different oils and resins is required to make a given surface enter the "anomalous" state. (see No. 572.)

- 563.** 1892. FISCHER, E. and SCHMIDMER, E. Rise of Salt Solutions in Bibulous Paper. *Lieb. Ann.* Vol. 282, p. 156-169. Also see *Amer. Jour. Pharm.* 1893, p. 289 and *Ber.d. Deutsch. ch. Ges.* 1893 Ref. p. 35-36.

According to the authors, the difference in capillary rise of water and dissolved substance in filtering paper is due to differences in diffusion velocities. Into a glass tube 70cm. long and 2cm. wide, six snugly fitting cylinders of rolled filtering paper, each 10cm. high, were inserted, forming a continuous column. The tube was set vertically several cm. deep into the solution experimented on, until the 5th cylinder was completely wet; then the glass tube was cut into pieces at the points of contact of the cylinders, and their contents washed out and analyzed. Of a NaCl-BaCl<sub>2</sub> mixture, NaCl diffused faster. Certain molecular compounds, such as FeSO<sub>4</sub>(NH<sub>4</sub>)<sub>2</sub> SO<sub>4</sub>. 6H<sub>2</sub>O, are dissociated in aqueous solution. This is in harmony with their behavior towards diffusion membranes.

- 564.** 1892. SCHMIDMER, E. *Ueber das Aufsteigen von Salzlösungen in Papier.* Dissert. Erlangen, 1892.

Covers the same subject as in No. 563. Compare Nos. 460, 259 and 578.

- 565.** 1892. LINEBARGER, C. E. Relations between the Surface Tensions of Liquids and their Chemical Constitution. *Amer. Jour. Science.* (3) Vol. 144, p. 83-92.

Guthrie's principle (see No. 276) of determining the weights of drops falling through a column of a lighter liquid, or determining the weights of drops of a lighter liquid rising through a column of a heavier one, is herein adopted in order to arrive at a method for comparing surface tensions. Water against a number of selected organic liquids practically insoluble in water, were the fluids operated upon. Two liquids which are partly miscible, e. g. water and nitrobenzene, only yield a uniform number of drops from a given volume if either liquid is previously saturated with the other. The tabulated results show striking regularities.

- 566.** 1892. CHABRIÉ, C. Sur le passage des substances dissoutes à travers les filtres minéraux et les tubes capillaires. *Comptes Rendus*, Vol. 115, p. 57.

The author's previous conclusion was to the effect that organic substances of high molecular volume pass less easily through capillary spaces than such of smaller volumes. The quantity of albuminous substances passing through fine capillary tubes suggests that their molecular weights should be much greater (10 or 15 times) than hitherto assumed.

- 567.** 1892. MEYER, G. Zur Theorie des Capillar-Electrometers. *Wied. Ann.* Vol. 45, p. 508-522.

When mercury is placed successively against different liquids in a capillary electrometer (see No. 343), the direction of the meniscus movement, upon introduction of Electromotive Forces, depends on whether the meniscus is made the Kathode or the Anode, and on the chemical nature of the electrolyte. The author operated on solutions of KOH, NaOH,  $\text{Na}_2\text{CO}_3$ ,  $\text{K}_2\text{CO}_3$  and KCl, tabulating the results of his experiments. A connection is expressed between electromotive forces (charging cathodically) and manometric pressures (which are proportional to surface tensions). The descending part of the curve representing this relation (compare Nos. 373, 529 and 530) is explained by the electrolytic formation of Potassium or Sodium-amalgam which reduce the surface tension of the previously pure mercury.

- 568.** 1892. BERTHOLD, G. Zur Geschichte des Leidenfrost'schen Phänomens, eine literar-historische Notiz. *Wied. Ann.* Vol. 47, p. 350-352.

Hermann Boerhaave [*Elementa Chemiae*, Lugd. Batav. 1782, Vol. I, p. 258] was the first to call attention very distinctly to the phenomenon of the spheroidal state exhibited for example by alcohol on red-hot iron. Musschenbroek (1762) credits Eller (1746) and Leidenfrost (see No. 28) with having described it.

- 569.** 1892. CANTOR, MATHIAS. Ueber Capillaritäts-Constanten. *Wied. Ann.* Vol. 47, p. 399-423.

The author employs two methods to determine surface tension (see No. 444). The first, that used by Sondhauss (see No. 388) exhibits in a specially devised apparatus, a well-defined and accurately measurable maximum of pulling force, from which the surface tension can be calculated. The second method consists in producing small drops of mercury in air or various fluids at the upper end of a tube having a sharp rim to eliminate the influence of a possible edge angle. The apparatus inversely allows the formation and measurement of air-bubbles against mercury. The maximum pressure consistent with the maintenance of the drop or the bubble is then determined, and the surface tension calculated from a formula herein developed. By the first method, the surface tensions of water and glycerine are determined; by the second, those of mercury against air, benzol, amyl alcohol and dilute sulphuric acid. The author finally discusses other capillary conditions, especially the connection between surface tension and temperature.

- 570.** 1892. MINCHIN, GEORGE M. *Hydrostatics and Elementary Hydrokinetics*. Oxford, 1892.

The subject of capillarity and molecular forces has received detailed treatment in Chapter VIII. (See Book review in *Nature*, Vol. 48, (1893) p. 457-458).

- 571.** 1893. SELBY, A. L. *Elementary Mechanics of Solids and Fluids*. Oxford, 1893.

See Book review in *Nature*, Vol 47 (1893) p. 315.

- 572.** 1892. POCKELS, A. Relations between the Surface Tension and Relative Contamination of Water Surfaces. *Nature*, Vol. 48, p. 152-154.

The author has previously shown (see No. 562) that the tension of a water surface which receives gradually increasing quantities of oily impurity, remains unchanged until the contamination reaches a definite value (the *normal* condition). Then the surface tension abruptly decreases, first rapidly, then gradually. In this state, every mechanical increase or decrease of surface layer alters the surface tension (the *anomalous* condition). The tension of water being taken as unity, that of a saturated solution of camphor was found to be 0.72, of a strong solution of soap 0.37 (compare No. 524). An equation and diagrams are given expressing the relation between the surface tension and relative contamination.

- 573.** 1893. HALL, T. PROCTOR. New Methods of Measuring the Surface Tension of Liquids. *Phil. Mag.* (5) Vol. 36, p. 385-413.



**Method A.** A film of water on a suitable rectangular glass frame suspended from one arm of a fine balance, is weighed, and the difference of weight in the same position of the frame, with broken film, is noted. This difference of weight, divided by twice the length of the film, gives the surface tension. **Method B.**, based on Wilhelm's principle (see No. 279) applies to Ether, Alcohol, Chloroform, etc., which Method A. excludes. Tables of results are given. **Method C.** is based on the observed fact that in separating a horizontal bar from the surface of a fluid, a maximum of pull is reached shortly before separation, which maximum point can be sharply observed (compare CANTOR, No. 569). By this method the surface tension of water was found to be 73.48-1407 in dynes.

- 574.** 1893. NICHOLS, E. F. Note on the Surface Tension of Liquids.

*Physical Review* 1893.

Not accessible.

- 575.** 1893. MENSBRUGGHE, VAN DER. Sur la pression hydrostatique négative et sur la cause commune de la tension superficielle et de l'évaporation des liquides. *Comptes Rendus*, Vol. 117, p. 359-361.

Contrary to the assumptions of Laplace and Poisson respectively, liquids cannot be considered as incompressible, and the free surface cannot be in equilibrium, because surface evaporation takes place continuously. On these principles, the molecular constitution of liquids is discussed, and the author's view is shown to conform to observed facts.

- 576.** 1893. RAMSAY, WILLIAM and SHIELDS, JOHN. The Molecular Complexity of Liquids. *Jour. Chem. Soc. Trans.* 1893. p. 1089-1109.

The capillary rise of liquids, inorganic and organic, is determined each at different temperatures that are maintained by surrounding the vessel containing the capillary tube with the vapors of different liquids of definite boiling points. In each case, an expression for the surface tension is calculated. This value, multiplied by the relative number of molecules contained in the unit of surface, yields an expression called the *molecular surface energy* of the liquid. This energy decreases linearly with increase of temperature except near the critical point where the sloping of the curve is less (compare No. 577). By measuring the temperatures downward from the critical temperature for each liquid, the resulting equation for the molecular surface energy is perfectly analogous to that expressing the well-known increase of the molecular or volume energy of gases with temperature.

The difference of the calculated molecular surface energies, divided by the difference of the corresponding temperatures, is a constant quantity. For  $\text{CS}_2$  this value  $K=2.622$ . If the value turns out to be smaller, this indicates association of molecules, and the degree of association can be calculated. Actual measurements are recorded in detail,  $\text{CS}_2$  being the example of a non-associating, formic acid of an associating liquid. The formula also allows calculation of critical temperatures, of which a table is given.

- 577.** 1893. RAMSAY, WILLIAM and SHIELDS, JOHN. The Variation of Molecular Surface Energy with Temperature. *Phil. Trans.* 1893 Vol. 184 A. p. 647-673.

A more detailed exposition of the subject of No. 576, with tables, and critical review of similar work by Eötvös (see No. 478.) The *molecular surface energy* is calculated from the capillary rise for ether, methylformate, ethylacetate, carbon-tetrachloride, benzene, benzylchloride, all of which prove to be non-associating liquids, and for acetic acid and methyl and ethylalcohol which are shown to be associating. The limit of possible coalescence of molecules seems to be 4; methylalcohol even at  $-89.8^\circ\text{C}$ . coalesces to not more than 4 molecules. Two sets of curves are constructed, one showing the variation of capillary rise and of surface tension with temperature, the other the variation of molecular surface energy with temperature.

- 578.** 1893. REED, L. On the Capillary Separation of Dissolved Substances. *Proc. Roy. Soc.* 1893, p. 123. Also see *Ber. d. Deutsch. Chem. Ges.* 1894. Ref. p. 559.

Demonstrates the separating action of filtering paper upon dilute solutions of salts and acids in water. In very dilute solutions of ferric chloride 1 in 30000 or sulphuric acid 1 in 4000 the dissolved substance hardly spreads at all, while with potassium bichromate even in dilute solution, no capillary separation between salt and water can be effected. Instead of paper, compressed porous bodies, e. g. Kaolin, may be used with the same effect. (Compare No 563).

- 579.** 1893. MENSBRUGGHE, VAN DER. Sur la cause commune de la tension superficielle et de l'évaporation des liquides. *Bull. Acad. Roy. Belg.* (3) Vol. 26, p. 37-71.

Not accessible.

- 580.** 1893. LOHNSTEIN, Th. Bemerkungen zu der Arbeit von M. Cantor. Ueber Capillaritäts-Constanten. *Wied. Ann.* Vol. 48, p. 207-208.

Cantor's statement (see No 569) that Sondhauss's method of measuring surface tensions (see No. 370) had not hitherto been investigated theoretically and that in consequence some essential points had been overlooked, is refuted.

- 581.** 1893. OBERBECK, A. Ueber die Eigenschaften dünner Oelschichten auf einer Wasseroberfläche. *Wied. Ann.* Vol. 48, p. 366-381.

The thickness of an oily layer on a large water surface sufficient to allay small ocean waves was determined by Sohnecke's method (see No. 531) and found to be 53 micromillimeters. The thickness of oily layers were then determined on a small scale in a rectangular trough. A pure water surface was obtained by a method communicated by Lord Rayleigh (see No. 526) i. e. by blowing a current of air against the surface. By successively adding very small and known amounts of oil with powdered sulphur as an indicator, the oily layer becomes impenetrable for a moderate air current or ether vapor (compare No. 532) at a thickness of about 2 micromillimeters and above. Extremely thin layers of oil seem to dissolve in the water surface.

- 582.** 1894. NEUMANN. *Vorlesungen über Capillarität.*

- 583.** 1894. RAMSAY, WILLIAM, and ASTON, EMILY. The Molecular Formulæ of some Liquids as determined by their Molecular Surface Energy. *Jour. Chem. Soc. Abst.* 1894, p. 167-173.

Investigations along the lines elaborated by Ramsay and Shields (see No. 576) show that phenol, like alcohols, form complex molecules in the liquid state; bromine is likewise associated but dissociates with rising temperature into simpler molecular groupings of  $\text{Br}_2$ . Nitric acid consists largely of molecular groups of  $(\text{NO}_3\text{H})_2$ . Sulphuric acid is very complex at ordinary temperature. It consists probably of not less than 32 molecules of  $\text{H}_2\text{SO}_4$ ; above  $132^\circ\text{C}$ . a rapid diminution of molecular weight is noticeable. Phosphorus in the liquid state has a molecular weight equal to that of its gas, expressed by  $\text{P}_4$ .

- 584.** 1894. TICKLE, T. Capillarity. *Pharm. Jour. Trans.* 1893-94, Vol. 24, p. 1055-1056.

A concise summary of the chief facts of capillarity, leading up to the results obtained by Ramsay and Shields (see No. 576.)

- 585.** 1894. WAALS, J. D. VAN DER. Thermodynamische Theorie der Capillarität. *Zeitsch. f. Physik. Chem.* Vol. 13, p. 657-715.  
Referred to by *Hulshof, Annal. der Physik* (4) Vol. IV (1901) p. 165.

- 586.** 1894. SENTIS, H. Sur la tension superficielle des solutions salines. *Comptes Rendus.* Vol. 118, p. 1132.

In a previous article on the surface tension of salt solutions (*Jour. de Physique*, 1887) the tension of water between  $0^{\circ}$  and  $30^{\circ}$  C. was found to be  $75.99 - 0.152t$ , in absolute measurement. The formula for the tension of salt solutions contains a factor which expresses the mutual action of salt and water molecules of known percentage, exercised along the unit of length. This factor is shown to be independent of temperature between  $0^{\circ}$  and  $25^{\circ}$  C., to be proportional to the number of salt molecules up to the highest concentration, and independent of the nature of the salt.

- 587.** 1894. PELLAT, H. Variation de la tension superficielle avec la température. *Comptes Rendus*, Vol. 118, p. 1193.

By applying the principles of thermodynamics to a given liquid mass, the author under certain assumptions demonstrates mathematically that the surface tension of a liquid in contact with its saturated vapor is a linear function of absolute temperature. This is in harmony with the conclusion arrived at experimentally by Ramsay and Shields (see No. 576).

- 588.** 1894. QUINCKE, G. Ueber die Messung der Oberflächenspannung des Wassers und Quecksilbers in Capillarröhren. *Wied. Ann.* Vol. 52, p. 1-22.

Nine different methods that have been employed by different authors for measuring surface tension (see No. 444) are enumerated and the values for water obtained by different authors are tabulated. The author seeks to explain existing discrepancies by instituting renewed and painstaking experiments, but cannot locate the cause with exactness. Different grades of glass gave different results for pure water; the surface tension in wider tubes was greater than in narrower ones of the same material. In flat drops and bubbles it gradually diminished to the point attained at once in capillary tubes. The possible solvent power of water for glass does not give an all-sufficient explanation. The edge-angle is finite and must be taken into consideration in calculating surface tension. Determined by an optical method, it was greater in older than in freshly drawn tubes. For mercury the author again finds a surface tension from about 10 to 50% higher than was found previously by other investigators (compare STOECKLE, No. 636.)

- 589.** 1894. QUINCKE, G. Ueber freiwillige Bildung von hohlen Blasen, Schaum und Myelinformen durch ölsäure Alkalien, und verwandte Erscheinungen, besonders des Protoplasmas. *Wied. Ann.* Vol. 53, p. 593-632.

The spontaneous formation of bubbles and foam in aqueous solutions of alkali oleates is herein considered in great detail, and the analogy of the resulting forms with the structure and motion of protoplasm is pointed out, even an analogy with the arrangement of the stars is hinted at.

- 590.** 1894. VOLKMANN, P. Ueber die Messung der Oberflächenspannung des Wassers in Capillarröhren aus verschiedenen Gläsern. *Wied. Ann.* Vol. 53, p. 633-663, and p. 664-666.

The author's experiments with capillary tubes of different material do not bear out Quincke's statement (see No. 588) to the effect that the material of the tube influences the magnitude of the surface tension of water. The more nearly cylindrical the tube, the more the surface tension (see No. 444) approaches a definite constant value, irrespective of the material. Contrary to Quincke's views, a greater surface tension is liable to be found in narrower than in wider tubes, and in well-cleaned tubes the edge-angle is zero. In an additional note (p. 664-666) former measurements of the surface tension of water (1830 and 1882) are recalculated on the basis of improved measurements of the radius of the capillary tubes then employed.

- 591.** 1894. KAISER, E. Das Zusammenfliessen zweier Flüssigkeitsmassen. *Wied. Ann.* Vol. 53, p. 667-683.

Two jets of water meeting from opposite directions (see No. 402) or two soap bubbles placed in contact with each other (see No. 509) frequently fail to coalesce, owing to intervening air. Upon approaching an electrified body, coalescence takes place. A theory is given for this phenomenon, and the floating of drops upon liquids of their own substance and its connection with Leidenfrost's phenomenon (compare No. 536) is discussed.



- 592.** 1894. MEYER, G. Capillarelektrometer und Tropfelectroden. *Wied. Ann.* Vol. 53, p. 845-873.

An extension of the author's preceding study of the relation between surface tension of mercury in contact with various solutions, and Electromotive force (see No. 567).

- 593.** 1894. LOHNSTEIN, Th. Zur Bestimmung der Capillaritäts-Constanten, Bemerkungen zu der Arbeit von Hrn. Quincke. *Wied. Ann.* Vol. 53, p. 1062-1073.

The author sides with Sieg (see No. 504) and others in pronouncing Quincke's method of measuring surface tension from flat drops and bubbles (see No. 312) as giving results too high. However by applying his own correction formulae developed herein and in a former paper (see No. 552), Quincke's recalculated values are seen to be more in accord with the lower results obtainable by observing the height of rise in capillary tubes.

- 594.** 1894. NATTERER, K. Capillary Rise of Sea Water in the Earth. *Chem. Centralblatt*, 1894, Vol II. p. 1014-1017.

This paper forms part of a series of "Chemical Investigations in the Eastern Mediterranean Sea, on board S. M. S. 'Pola' in the year 1893." The fact that the muddy ocean sediment contains large quantities of organic matter and ammonium salts, which are absent in the water immediately above it, leads the author to theorize regarding capillary rise of the lower water stratum into the surrounding continental masses, and consequent deposition of salt, formation of petroleum, exhalations of  $\text{CO}_2$  or  $\text{SH}_2$ , etc.

- 595.** 1894. SUTHERLAND, WILLIAM. The Attraction of Unlike Molecules. *Phil. Mag.* (5) Vol. 38, p. 1-19 and 188-197.

The author endeavors to find the general law of attraction between two unlike molecules, through the study of the diffusion of gases and the surface tension of mixtures of liquids. Both lead him to a law perfectly analogous to that previously announced for the attraction of like molecules (see No. 515). This law he verifies partly from data by Rodenbeck (see No. 403), and for the greater part from his own observations of the capillary rise of water and a dozen organic liquids, and mixtures prepared therefrom. He follows Elsworth's method (see No. 505) using an inclined capillary tube; the difference being that he makes the capillary length constant by adjusting the inclination accordingly.

- 596.** 1894. MOORE, B. On a Relation between the Surface Tension and Osmotic Pressure of Solutions. *Phil. Mag.* (5) Vol. 38, p. 279-285.

While the laws of osmotic pressure are well recognized, its cause is unknown. The author shows how it can be traced to difference in surface tension acting along the exceedingly fine capillary openings of almost molecular dimensions in the diaphragm that separates solvent from solution. The reasoning leads to a calculation of the diameter of these pores which come well within the radius of molecular action. The author finally adduces experimental evidence in support of several laws to which his theory leads.

- 597.** 1894. RAMSAY, W. and ASTON, E. Molecular Surface Energy of Ethereal Salts and of Mixtures of non-associating Liquids. *Jour. Chem. Soc. Abst.* 1895, p. 40, from *Proc. Roy. Soc.* 1894, Vol. 56, p. 162-170, 171-182 and 182-191.

With ethereal salts (esters) the constant factor K in the equation of Ramsay and Shields (see No. 576) does not differ greatly from the mean value 2.121 for non-associating liquids, although it increases slightly with molecular weight.

The second paper contains a summary of previously established facts regarding complexity and dissociation of liquid molecules.

The change of molecular surface energy with temperature was finally examined and found to be fairly constant for mixtures of toluene and piperidine, benzene and carbon tetrachloride, chloroform and carbon disulphide. With the latter mixture, slight association was noticeable at low temperatures.

- 598.** 1895. SUTHERLAND, W. Molecular Force and the Surface Tension of Solutions. *Phil. Mag.* (5) Vol. 40, p. 477-494.

The results of this paper present further confirmation, resp. an extension of the author's previous important papers and conclusions (see No. 595).

- 599.** 1895. BRILLOUIN, M. Tensions superficielles et Formes cristallines. Domaine d'action Moléculaire. *Ann. Chim. Phys.* (7) Vol. 6, p. 540-574.

A general discussion of molecular action in solids and in liquids in contact with solids: surface tension being a consequence of the limitation of the sphere of molecular action. The influence of surface tension on the stability of solid edges is discussed, and the reason is given why for example, the edges in convex glass lenses break easily, even when their angle is  $60^\circ$  or more. In this case, as well as with agate knife edges in fine balances, two auxiliary surfaces are substituted forming a stable angle of about  $120^\circ$ . Finally the author discusses the influence of surface tension on the growth of crystals.

- 600.** 1895. POINCARÉ, H. *Capillarité*. Paris, 1895.

- 601.** 1895. RISTEEN, A. D. *Molecules, and the Molecular Theory of Matter*. Boston, 1895.

On p. 86-95, the author gives a unique review of surface tension, phenomena of films and other surface phenomena. On p. 142-145, the magnitude of molecular diameters is discussed, based on consideration of surface tension, the motion of camphor on water (see No. 562) and closely related subjects.

- 602.** 1895. FROST-BLACKMAN, F. Experimental Researches on Vegetable Assimilation and Respiration. *Phil. Trans.* Vol. 186 B. (1895) p. 485-502 and 503-562.

The first part describes in detail a rather complicated arrangement by means of which the quantities of carbonic acid evolved from plants can be continuously and conveniently titrated with baryta water. This method is made use of in the second part to study the paths of gaseous exchange between aerial leaves and the atmosphere. The general result of these elaborate papers is that under normal condition, practically the sole pathway for  $\text{CO}_2$  into or out of the leaf is by the stomata. Incidentally, the solubility of  $\text{CO}_2$  in oils and waxes supposed to be insignificant, was determined and the results are tabulated. An elaborate bibliography is appended.

- 603.** 1895. MENSBRUGGHE, VAN DER. L'évaporation des liquides et les grandes théories capillaires. *Comptes Rendus*, Vol. 121, p. 461.

Evaporation of liquids involves the necessary conclusions of diminished density in the surface, of loss in volume and absence of equilibrium. These facts are in contradiction to the postulates of the capillary theories of Laplace, Gauss, Poisson, etc. The author charges physicists with having neglected evaporation in their explanations of capillary phenomena. Furthermore he considers the contractile surface force in liquids rather a reality than a convenient assumption.

- 604.** 1895. THADDEEFF, K. Ueber gewisse aus dem Gewichte der Tropfen geschmolzener Metalle sich ergebende Gesetzmässigkeiten. *Ber. d. Deutsch. Chem. Ges.* Vol. 28, p. 195-202.

The weights of melted drops of one and the same metal were found to be fairly constant. The author determined the weights of drops of Pb, Bi, Sn, Cd, Zn and Sb. Multiplying these weights with the atomic weights, and taking care that the dropping ensues from a surface of uniform size, the product will be the same for the first 5 metals, while the value for antimony is exceptional, viz., one-third. Similar observations have been made by Quinke and by Dupré (see Nos. 302, 304 and 285). Quinke states his observation for salts as follows: With compounds of analogous composition, the products of drop weight and molecular weight are almost an equal quantity.

- 605.** 1895. MOND, L., RAMSAY W. and SHIELDS, JOHN. On the Occlusion of Oxygen and Hydrogen by Platinum Black. Part I: *Phil. Trans.* 186 A. (1895) p. 657-693. Part II: *ibid.* 190 A. (1897), p. 129-153.

The authors come to the following conclusions: For Pt-foil and Pt-sponge, Graham's observations (*Phil. Trans.* 1866, p. 399) are generally confirmed. Pt-black was shown to retain 100 volumes of Oxygen even after being dried at 100°C. A further quantity of O is absorbed upon heating as high as 360°C. Above this temperature most of the gas is given off at 400°C. *in vacuo*; but red heat only will remove it all. Platinumblack charged with oxygen will absorb about 810 vols. of Hydrogen, i. e. 110 vols. above the volume necessary to form water. Hydrogen is given off immediately from Platinum black on warming; its bulk can be extracted at 300°C. *in vacuo*. In Part II the authors state that any given sample of Pt-black occludes approximately the same volume of the different gases (H, O, CO, SO<sub>2</sub>), pointing to a surface action of Platinum; N and CO<sub>2</sub> are absorbed in small quantity. For oxygen, indications are of the formation of a definite oxide. In a subsequent paper (*Phil. Trans.* 191 A. (1898) p. 105-126) the authors treat of the occlusion of O and H by Palladium.

- 606.** 1895. DIXON, HENRY H. and JOLY, J. On the Ascent of Sap. *Phil. Trans.* 186 B. (1895) p. 563-576.

The authors accept that the suction force of the leaf is the all-sufficient cause of the elevation of sap, not by establishing differences in gas pressure, but by exerting a simple tensile stress on the liquid in the conduits. The presence of dissolved air does not interfere with the attainment of high tensions. The authors show how the leaves can draw up and evaporate water against a surrounding pressure of 2 to 3 atmospheres. The peculiar structure of the wood aids in maintaining the tensile capacity of the sap even if air is interposed (compare No. 443).

- 607.** 1895. RANDALL, W. W. The Molecular Complexity of Liquids. *Amer. Chem. Journal*, Vol. 17, p. 461-470.

A detailed presentation of the paper by Ramsay and Shields (see No. 576) and connected papers.

- 608.** 1895. HANNAY, J. B. On Drops. *Pharm. Jour. Trans.* 1894-95, Vol. 25, p. 1018 and 1121-22.

Tate's conclusion (see No. 281) that the size of a drop is proportional to the diameter of the delivery tube, is verified; also Traube's analogous law (see No. 489) holds good for salt solutions, such as KI, KNO<sub>3</sub>, K<sub>2</sub>SO<sub>4</sub> and MgSO<sub>4</sub>. A normal drop of water measures 0.108 cc. but when dropping in benzene vapor at 37°C. its volume is 0.0449 cc. The author concludes that "the weight of a normal, i. e. an infinitely slow drop is controlled by its surface tension or contractility, while when dropping in practice, it is modified by the rate of flow, by its gravity, the viscosity of the medium in which it drops, and by its rate of fall, all of which affects the life time of the closing neck."

- 609.** 1895. LOHNSTEIN, Th. Zur Berechnung der Capillaritäts-constanten aus Messungen an Tropfen mittlerer Grösse. *Wied. Ann.* Vol. 54, p. 713-723.

The capillary constants of Mercury in air and dilute sulphuric acid were determined by Meyer, (following A. König see Nos. 592 and 423) by measuring the radius of curvature of rather small drops of mercury at their summit, and their greatest horizontal width, and inserting these values into a formula given by Poisson (see No. 118). Since the latter formula holds good only for large drops, Meyer's results must be faulty. The author inserts Meyer's data into 2 of his own formulae previously elaborated (see No. 593) and obtains considerably lower corrected values for the surface tension of mercury in air and against 8% sulphuric acid. (Compare J. Stöckle, No. 636).

- 610.** 1895. VOLKMANN, P. Beiträge zur Feststellung der wahren Oberflächenspannung des reinen Wassers für Temperaturen zwischen 0° und 40° C. *Wied. Ann.* Vol. 56, p. 457-491.



By a series of most painstaking experiments the author arrives at a standard set of values for the surface tension of pure water for definite temperatures between  $0^{\circ}$  and  $40^{\circ}\text{C}$ . Special precautions are taken to insure uniformity of the temperature of the *meniscus*, since the latter (which dominates the height of rise) is very sensitive to temperature; less narrow capillaries are therefore preferable. Contrary to Quincke's statements (see No. 58\*) the material of the glass has no influence upon the surface tension of water, neither is the latter influenced by the width of the capillary tube. These experiments were not made with air-free water.

- 611.** 1896. LINEBARGER, C. E. An Apparatus for the Rapid Determination of the Surface Tensions of Liquids. *Amer. Journal of Science*, Vol. 152, p. 108-122.

Simon (see No. 202) calculated surface tension by measuring the pressure necessary to force bubbles of air out of the lower end of a capillary tube. The pressure employed counteracts the capillary pressure due to surface tension and the hydrostatic pressure at the lower end of the tube. This method was modified by G. JAEGER (*Wiener Acad. Ber.* 1891, p. 245) and was adopted by the author. Two capillary tubes of different bore are employed, the narrower being movable. The liquid column in both is depressed by means of a rubber bulb. The narrower tube is raised until bubbles issue from both tubes at the same speed.

- 612.** 1896. LINEBARGER, C. E. On the Surface Tension of Mixtures of Normal Liquids. *Amer. Jour. Science*, Vol. 152, p. 226-228.

Ramsay and Aston (*Zeitschr. f. phys. Chem.* Vol XV, (1894) p. 89) determined the molecular surface energies of liquids that do not undergo appreciable polymerization; in some instances, the molecular surface energy of the mixture was the mean of the energies of the component liquids. The author determined that the rule of alligation can be applied to the surface tension of mixtures of Benzene and Toluene; but in the majority of cases, the surface tensions of mixtures of normal liquids cannot thus be calculated. The difference of level of the lower orifices of the tubes (see No. 611) is then an element in the calculation of the surface tension of the liquid. Jäger's formula, giving only approximate results, is substituted by a formula of the author, the correctness of which is verified by using the results of Ramsay and Shields (see No. 576).

- 613.** 1896. LINEBARGER, C. E. On the Viscosity of Mixtures of Liquids. *Amer. Jour. Science*, Vol. 152, p. 331-340.

The researches of Girard, Poiseuille, Graham, Wykander, (*Wied. Ann. Beibl.* Vol. III, 1879, p. 8) Traube, etc., are outlined (see Nos. 84, 162, 254 and 489). Elaborate tables by the author tend to confirm Wykander's results, according to which no maximum of viscosity is noticeable in mixtures of normal (non-associating) liquids. Mixtures showing a maximum have at least one associating constituent and with increase of temperature the maximum becomes less pronounced. Discusses the sometimes considerable differences between observed viscosities and those calculated by the rule of mixtures.

- 614.** 1896. SCHOTT, O. Ueber electrisches Capillarlicht. *Wied. Ann.* Vol. 59, p. 768-772.

If the spark of an induction coil of 25cm. spark length, is passed through a capillary tube of 0.65 to 0.68 mm. inner diameter and 60 mm. length, a brilliant light is obtained of greater specific intensity than arc light. Gradually, however, the tube becomes warm, even hot, the light is dimmed, and the inner surface of the tube becomes rough. The spark passes through compressed air with difficulty; but if the capillary tube is evacuated, the spark passes easily and the light gradually becomes blue. The light is probably very rich in ultraviolet rays.

- 615.** 1896. GENTSCH, WILHELM. Glättung der See. *Chemiker Zeitung*, 1896, No. 91, p. 911. From *Dingler's polyt. Journal*, Vol 299, p. 58-62 and 73-76.

An interesting critical discussion of theory and practice concerning the calming influence of oil upon waves. Special theoretical literature quoted are e. g. Joseph Grossmann, *Die Bekämpfung der Sturzwellen durch Oel und ihre Bedeutung für die Schifffahrt*, Wien, 1892 and M. M. Richter, *Die Lehre von der Wellenberuhigung*. Regarding the latter, see also Review in *Nature*, Vol. 49, p. 488, March 22, 1894.

- 616.** 1896. VERSCHAFFELT, J. Capillary Rise of Liquid Carbonic dioxide near the Critical Temperature. *Zittingsversl. Kon. Akad. v. Wetensch. Amsterdam*. 1894-1896. Comm. from phys. Lab. Leyden, No. 18 (1895), and Nos. 28 and 32 (1896). Also see *Nature*, Vol. 54, p. 360.

The capillary rise of liquid  $\text{CO}_2$  decreases in nearly linear measure with temperature as far as  $30^\circ\text{C}$ ; between  $30^\circ$  and  $31^\circ\text{C}$ . (the critical temperature for  $\text{CO}_2$ ) the height-of-rise curve must incline somewhat more towards the temperature axis. The surface energy of the liquid is then calculated and compared with the theory of Van der Waals (see No. 585.)

- 617.** 1896. LANGLOIS, MARCELLIN. Sur une Nouvelle Théorie Capillaire. *Comptes Rendus*. Vol. 123, p. 35 and 87.

Only the title of this memoir is herein given, with the note that the second memoir published in the French Academy transactions contains "the fundamental law of the surface tension of liquids and the explanation of the very origin of this tension" from the point of view of thermochemistry. Thereto is added "the long-sought relation between the surface tension and heat of vaporisation."

- 618.** 1897. HUEFNER, G. Ueber die Bestimmung der Diffusions-Coeffizienten einiger Gase für Wasser. *Wied. Ann.* Vol. 60, p. 134-168.

A detailed summary of previous work on the determination of diffusion coefficients of some gases into water is given. Then the author proceeds to measure diffusion coefficients for  $\text{CO}_2$ , H, O, N,  $\text{N}_2\text{O}$  and Cl, partly by using capillary tubes, partly by operating with wider tubes closed at the lower end by a thin diaphragm of the opal-like mineral *Hydrophan*, the use of which for this purpose was first suggested by Reusch (1865). By allowing the gas to enter the lower end of the liquid column, disturbing currents due to difference in specific gravity are avoided. The results together with those of other investigators, are tabulated.

- 619.** 1897. VOLKMANN, P. Ueber nothwendige und nicht nothwendige Verwerthung der Atomistik in der Naturwissenschaft. *Wied. Ann.* Vol. 61, p. 196-202.

Includes Meditations on the importance of Capillary theory for the molecular theory. Incidentally, Mensbrugghe's objections (see No. 603) are considered as not valid, since evaporation is a dynamic, capillarity a static phenomenon; even W. Thomson's theorem (see No. 319) treats the connection between vapor pressure and capillarity from the static point of view.

- 620.** 1897. SIEDENTOPF, HENRY. Ueber Capillaritätsconstanten geschmolzener Metalle. *Wied. Ann.* Vol. 61, p. 235-286.

The capillary constants ("specific cohesion" see No. 466) of Hg, Cd, Sn, Pb, Bi and alloys in their molten state are calculated from measurements of the greatest diameter of drops formed by the metals, and the radius of curvature at their summits obtained by an optical method (see Nos. 470 and 478). Incidentally, part of the elaborate tables of Bashforth and Adams (see No. 431) covering the same subject, are verified. No connection is apparent between specific cohesion, or surface tension and melting points or specific gravities; the temperature coefficient, denoting decrease of surface tension with heat, is approximately the same as the coefficient of expansion. Quincke's results for Cd, Sn, Pb, Bi, determined by the method of falling drops (see No. 302) are all slightly lower; that for mercury (see No. 588) is higher than the author's. The latter doubts the absolute correctness of Quincke's law of specific cohesions (compare No. 621).

- 621.** 1897. QUINCKE, G. Moderne Kritik der Messungen der Capillaritätsconstanten von Flüssigkeiten und die spezifische Cohäsion geschmolzener Metalle. *Wied. Ann.* Vol. 61, p. 267-280.

A polemical paper in which the author upholds all his former conclusions against the criticisms of Volkmann, Siedentopf, Lohnstein and Sieg (see Nos. 593, 620 and 504). Against Siedentopf, he upholds his law of the specific cohesion of molten metals (see No. 304) and reiterates it as follows: At the melting point of each metal the specific cohesion is  $1 \times 8.5 \text{ mm}^2$  for Hg, Pb, Bi, Sb;  $2 \times 8.5$  for Ir, Pt, Au, Ag, Sn, Al,  $\text{H}_2\text{O}$ ;  $3 \times 8.5$  for Pd, Rh, Cu, Ni, Co, Fe, Zn;  $4 \times 8.5$  for K,  $7 \times 8.5$  for Na. Finally the many different values for the surface tension of mercury obtained by different observers, are tabulated, and the cause of the discrepancy is stated to be unknown. (Compare No. 620).

- 622.** 1897. BOYS, C. V. Capillary Ripples. *Pharm. Jour. Trans.* Vol. IV. (1897) p. 115.

In large waves, gravitation and the property of buoyancy play the principal part, but in small liquid waves (ripples) excited by a tuning fork (see Nos. 527 and 664) capillarity alone predominates. Capillary ripples move with such rapidity (e. g. 200 oscillations per second) that they cannot be seen with the unaided eye. It is only by means of a mechanical device (viz. looking at the waves through a series of revolving apertures following each other at the same speed i. e. 200 per second) that the waves can be seen and conveniently studied. These beautiful phenomena were rendered visible to an audience.

- 623.** 1897. DARWIN, FRANCIS. On the Ascent of Water in Trees. *Nature*, Vol. 56, p. 307-310.

According to Prof. Strassburger (*Leitungsbahnen*, 1891; and Ueber das Saftsteigen, in *Histolog. Beiträge*, Vol. V (1893) p. 50) the modern theory regarding the rise of sap may be expressed as follows:

The sun's heat causes evaporation of the water which the mesophyll cells have imbibed; this water is replaced by imbibition from the cell sap. The concentration of the cell sap so produced maintains the osmotic force of the cell, which in turn exerts suction on the water in the tracheal cells.

- 624.** 1897. BARENT, ST. Capillary Behavior of the Crystal-Faces of Rock salt and Sylvine towards the Mother Liquors. *Jour. Chem. Soc. Abst.* 1897, p. 9, from *Zschr. f. Kryst. und Min.* Vol. 26, (1896) p. 529-557.

The growth and form of crystals in their mother liquors are determined by the number of mass points on unit area of the faces of the crystal. A greater number of such mass points involves a lesser capillary constant. The author shows that different plates of rock salt and of sylvine (KCl) according to the crystallographic faces which they represent, under equal conditions of temperature, etc., have different capillary behavior i. e. different edge angle towards saturated aqueous solutions of their own substance. The addition of urea and other substances alters the edge angle. This explains why NaCl crystallizes from urine in octohedra instead of cubes.

- 625.** 1897. PAYNE, GEO. F. Variation in the Size of Drops of the Same Liquid. *Merck's Report*, Vol. 6, p. 401.

The author shows the accepted statement that one fluid drachm of water yields 60 drops, to be practically unreliable. By different modes of dropping, from 18 to 600 drops could be obtained from one fluid drachm, and a variation between 33 and 120 drops is considered to be easily obtainable. The causes of these variations are discussed, and measurements of small quantities by the minim or the 10th of a cubic centimeter are recommended.

- 626.** 1897. DORSEY, N. ERNEST. Surface Tension of Water and of Dilute Aqueous Solutions. *Phil. Mag.* (5) Vol. 44, p. 134-135 and 369-396. From *Johns Hopkins University Circulars*, June, 1897. Also see *Jour. Chem. Soc. Abst.* 1898, p. 17.

The method of ripples (see No. 622) is employed in a more sensitive form so that deviations are only  $\frac{1}{10}\%$ , while Lord Rayleigh's deviations were about 2%. The surface tensions of water and solutions of NaCl,  $\text{Na}_2\text{CO}_3$ ,  $\text{K}_2\text{CO}_3$ , and  $\text{ZnSO}_4$  were determined, the salt solutions being in concentrations of from 0.05 normal to normal volumetric. For water, the value 75.98 dynes per cm. at  $0^\circ\text{C}$  was obtained, while Sentis (1887) had found 76.09 by a different method. (See No. 586.) The surface tensions of dilute aqueous solutions were found to be linear functions of the concentration.

The following is among the literature quoted on the surface tension of aqueous salt solutions: KILPATRY, *Ann. d. Phys. Beibl.* Vol. XII, (1888) p. 750; CANESTRINI *ibid.* Vol. XVI (1892) p. 335, from *Riv. sc. ind.* (1892) p. 33; N. KASANSKINE, *Jour. de Phys.* (3) Vol. I (1892) p. 406; SENTIS, *ibid.* (2) Vol. VI (1887) p. 571; *ibid.* (3) Vol. VI, (1897) p. 183.

- 627.** 1897. HERZFELD, RUDOLF. Bestimmung der spezifischen Cohäsion für Kupfer, Eisen, Nickel und Cobalt. *Wied. Ann.* Vol. 62, p. 450-452.

Upon request of Quincke the author decided the following point in Quincke's law of specific cohesions (see No. 621): Does Cu belong to the second, Fe to the third group as Quincke at one time supposed? Upon examining pure drops of Cu, Fe, Ni, Co, melted in the arc light, it was found that the specific cohesion of these metals is three times that of mercury, hence all belong to the 3rd group.



- 628.** 1897. VOLKMANN, PAUL. Bemerkungen zu meinen beiden Arbeiten über die Oberflächenspannung des reinen Wassers aus den Jahren 1894 und 1895. *Wied. Ann.* Vol. 62, p. 507-521.

The author repeated Quincke's experiment, measuring the edge angle of water against glass by total reflection of light. The method gives useful results for finite edge angles greater than  $3^\circ$ ; Whether these  $3^\circ$  observed are due to an edge angle is doubtful. In concordance with former results, the edge angle of water against glass in well cleaned tubes was found to be zero.

- 629.** 1897. HEYDWEILLER, ADOLF. Spezifische Cohäsion und Oberflächenspannung des erstarrenden Goldes. *Wied. Ann.* Vol. 62, p. 694-699 and 700-701.

A congealed gold button containing 99.5% gold and of quite regular shape was measured and the specific cohesion calculated from the data thus obtained (compare No. 304). The resulting value, however, is considerably less, almost one-third of that found by Quincke (see No. 302), whose results he holds doubtful, claiming his specimen to have been impure, judging from its apparently low specific gravity. Besides, the modern correction formulæ of Worthington and Lohnstein (see Nos. 474 and 609) established for large drops, yield too high values for Quincke's small-sized drops.

- 630.** 1898. QUINCKE, G. Ueber die Oberflächenspannung des reinen Goldes. *Wied. Ann.* Vol. 64, p. 618-619.

The author upholds the correctness of his determination of the specific cohesion of gold, which was doubted by HEYDWEILLER (see No. 629). The specimen on which he operated was the very purest available. On the other hand, Heydweiller's specimen having contained 99.5% gold, the author says that much smaller quantities than 0.5% impurities can vitiate the height of flat drops, and thus impair the result for the specific cohesion of noble metals. The author has always found the heights of flat drops of pure gold, silver and platinum to be equal to the height of air bubbles of equal diameter in water, hence identity of specific cohesion irrespective of any correction formula (compare No. 474).

- 631.** 1898. STARK, J. Bemerkung zur Leidenfrost'schen Erscheinung. *Wied. Ann.* Vol. 65, p. 306-310.

The oscillations and contact phenomena of water or solutions of  $\text{ZnCl}_2$  and  $\text{CuSO}_4$  on heated brass or silver plates (compare No. 536) are studied by making the drop and the plate part of an electric circuit supplied by a storage battery of 8 volts, and inserting a telephone. Near the boiling point, the oscillations and intermittent contacts are indicated by a rattling noise while at higher temperatures, where the intervening vapor layer is thicker, no noise is heard. The up-and-down oscillations are due to a local diminution of surface tension at the point nearest to the source of heat, which causes transient deformations of the drop; the whirling motion of the drop is due to the same cause, i. e. the difference of the tensions prevailing at the bottom and the summit of the drop which results in a continuous transportation of the lower water particles to the top where it evaporates.

- 632.** 1898. STARK, J. Ueber Ausbreitung von Flüssigkeiten und damit zusammenhängende Erscheinungen. *Wied. Ann.* Vol. 65, p. 287-305.

The author produces numerous interesting experiments to illustrate the rule that a liquid [3] will expand on the common surface of two others [1 and 2, one of which may be air.] if the common surface tension between 1 and 2 is greater than the sum of the tensions between 3 and 1, and 3 and 2. To render the currents visible, gas soot suspended in alcohol was frequently used. The influence of temperature on surface tension is illustrated, and the centrifugal motion of the melting "stearin" in a burning candle is explained; further points treated of are the spreading of miscible liquids, and of partially miscible liquids; the action of vapors on surface tension; the repulsion of water films by alcohol, expansion of sooted alcohol on the common surface of oil and water, etc.

- 633.** 1898. HEYDWEILLER, ADOLF. Ueber die Bestimmung von Capillarconstanten aus Tropfenhöhen. *Wied. Ann.* Vol. 65, p. 311-319.

The capillary constant of liquid drops, i. e. "specific cohesion" of Quincke (see No. 466) can be calculated from geometrical data of the drop, viz., its greatest horizontal diameter, and its "height," i. e. the vertical distance of its summit from the plane of this diameter, and inserting the data into formulæ recently given by Lohnstein and by Siedentopf (see No. 620). The author has drawn up a table

which states the values of "specific cohesions" for definite dimensions of drops of all sizes, and verifies his table by recalculating many determinations of "specific cohesion" for mercury and water made by previous observers. With Quincke's cohesion of congealed silver drops the results are not uniform, probably owing to deformation of outline due to occluded gases. According to the behavior of Sn-Bi alloys, examined by Siedentopf, metallic admixtures (impurities) do not sufficiently account for this variation.

- 634.** 1898. HAGENBACH, AUG. Ueber Diffusion von Gasen durch wasserhaltige Gelatine. *Wied. Ann.* Vol. 65, p. 673-706.

A 20% gelatine fluid and water absorb  $\text{CO}_2$ ,  $\text{N}_2\text{O}$ ,  $\text{H}_2\text{S}$ ,  $\text{NH}_3$  and O in about the same quantities. The constants of diffusion of these gases into gelatine are about 66% of the corresponding values for the same gases into water. EXNER'S rule, (see No. 363) according to which the diffusing gas volumes are proportional to their coefficients of absorption and inversely proportional to the square roots of their densities, holds good only approximately.

- 635.** 1898. VOLKMANN, P. Studien über die Oberflächenspannung des Wassers in engen Capillarröhren. *Wied. Ann.* Vol. 66, p. 194-208.

Contrary to Quincke's observations (see No. 588) the surface tension of water in freshly-drawn capillary tubes gives very concordant results, independent of substance and width of the tubes. Freshly drawn tubes whether used at once or kept immersed for a long time in water, show a very slightly greater capillary constant than old, wide tubes previously well cleaned. The increase is believed to be due not to the possible existence of a small edge angle,  $4\frac{1}{2}^\circ$ , in the old tubes, but rather to a slight solubility of glass substance in the freshly drawn tube at the contact line of the meniscus. At any rate, the increase either falls within or just touches the limit of error of observation. (Compare No. 628.)

- 636.** 1898. STÖCKLE, J. Ueber die Oberflächenspannung des Quecksilbers. *Wied. Ann.* Vol. 66, p. 499-522.

This important paper plainly indicates the cause of the much-discussed discrepancy in the values for the surface tension of mercury obtained by different observers. The surface tension of mercury against a vacuum is constant; its value is 44.4 mg | mm. In contact with gases, the surface tension of freshly formed surfaces is markedly higher, but upon standing it decreases, approximating or falling below the vacuum value; the decrease takes place rapidly in a hydrogen atmosphere, slowly in nitrogen. The decrease cannot be explained by the action of fatty material, but can be sufficiently explained by the condensation of gas upon the mercurial surface. The author's highest initial value for mercury against air was 49.4, which is probably still below the true value, Quincke's (1894) result, being 55.78, indicates minimum of air absorption (see No. 588).

- 637.** 1898. MEYER, G. Die Oberflächenspannung von Quecksilber gegen Gase. *Wied. Ann.* Vol. 66, p. 523-529.

Stöckle's initial values for the surface tension of mercury in gases (see No. 636) are most probably too low, because his method did not allow immediate readings. The author obviates this source of error by employing Rayleigh's method of jets, (see No. 492) which allowed immediate readings. For mercury against hydrogen, his initial value is 56.5 mg. | mm., that of Stöckle 47.9; for mercury-air he finds 51.5, Stöckle, 48.8. Hence values obtained with pure surfaces are above 50; those below 50 are obtained with surfaces having already absorbed gas.

- 638.** 1898. TROUTON, F. T. Measurement of Surface Tension of Liquids. *Nature*, Vol. 58, p. 191.

The method employed depends on the rate at which a column of liquid fills or empties a capillary tube when the vessel containing the bulk of the fluid is raised or lowered (compare No. 320). Experiments were also made with soap solutions, the surface tension of which varies with time (compare No. 521).

- 639.** 1899. ARCHBALD, E. H. On the Relation of the Surface Tension and Specific Gravity of certain Aqueous Solutions to their State of Ionization. *Amer. Jour. Science*, Vol. 157, p. 313.

A general formula by Prof. McGregor, expressing either density or surface tension of NaCl or KCl solutions as a function of the same values for water, and the molecular concentration and ionic electrolytic dissociation of the solution, is herein extended to simple solutions of sulphates of sodium, potassium and copper and mixtures thereof. The equation given holds good for observed values of the surface tension and specific gravity of the simple solutions, for concentrations

ranging from 0.05 to 0.5 gram-equivalents per liter. Besides, the surface tension and the specific gravity of mixtures of  $K_2SO_4$  and  $Na_2SO_4$  solutions can be predicted throughout nearly the same range of concentrations, likewise the specific gravity of mixtures of  $K_2SO_4$  and  $CuSO_4$ , and of  $K_2SO_4$  and  $KCl$ .

- 640.** 1899. POCKELS, AGNES. Untersuchung von Grenzflächen-spannung mit der Cohäsionswaage. *Wied. Ann.* Vol. 66 p. 668-681.

In continuation of her former work (see No. 572) the author determines the interfacial tension (tension of the common surface) between water and oil or benzene, petroleum benzin, ether, etc. by two methods: (1) The *direct* method, i. e. by means of adhesion rings (compare No 870). It is applicable only if the ring is wetted by the lower liquid, which is not the case for example with alcohol and oil, because the oil displaces the wetting alcohol from the ring. (2) The *indirect* method which consists in rendering a pure water-surface "anomalous" i. e. impure by depositing on its surface a thin oil-film of known surface tension, and after expansion of the film has ceased, determining the diminished surface tension of the water by the cohesion balance. Subtracting from this value the surface tension of the pure oil, yields the tension of the common surface. Several tables are given containing the results of these painstaking researches.

- 641.** 1899. GRADENWITZ, A. Ueber die Bestimmung von Capillar-constanten an erstarrten Tropfen. *Wied. Ann.* Vol. 67, p. 433-438.

From the measurement of the geometrical outline of congealed and liquid drops conveniently traced by parallel screen projection, Quincke's "specific cohesion" may be calculated according to tables by Heydweiller (see No. 633). Measurements were made with mercury at  $15^\circ C$ , water at  $18^\circ$  on a paraffined surface, frozen drops of water and congealed drops of silver. The deformations which often take place when drops of molten metals congeal, render this method of determining capillary constants somewhat uncertain. For this reason, Herzfeld's values (see No. 627) are considered unreliable.

- 642.** 1899. FISCHER, KARL T. Die geringste Dicke von Flüssigkeits-häutchen. *Wied. Ann.* Vol. 68, p. 414-440.

The author tabulates the results of similar work by Plateau, Sohncke, Rayleigh, Roentgen, Oberbeck, Drude, Reinold and Rücker (see *index of authors*, below), and seeks to explain Sohncke's result that an oily layer of uniform thickness on water cannot be thinner than 100 micromillimeters. Operating on a surface of pure mercury on which rape-seed oil, olive oil, glycerine-water mixture, dilute sulphuric acid are severally allowed to spread, no disintegration of the film was ever noticeable during the spreading of the fluids, but always afterwards, while Sohncke noticed a different effect with water. The author obtained with the four fluids films of uniform thickness equal to less than 5 micromillimeters.

- 643.** 1899. WALLBOTT, HEINRICH. Ein optischer Nachweis der zur Wand senkrechten Componenten der Oberflächenspannung. *Wied. Ann.* Vol. 68, p. 496-499.

When a mercury surface is in contact with a vertical glass wall, the vertical component of the surface tension of mercury manifests itself by the curvature of the mercurial edge, but the horizontal component, tending to pull the glass surface horizontally, has no visible effect, owing to the rigidity of the glass. But if a moist gelatine film is inserted between the mercury and the glass, as was done by the author for the purpose of studying phenomena of the interference of reflected light, the horizontal component of the surface tension causes the gelatine at the point of contact to be pulled outward, a deformation which first manifested itself in a disturbance of the interference phenomena. A graphic explanation of the phenomenon is given.

- 644.** 1899. IMASS. Ueber den Randwinkel.

Dissertation, mentioned in *Chemiker Zeitung*, 1899, No. 67, p. 695.

- 645.** 1899. LINEBARGER, CHAS. E. Surface Tensions of Solutions of Alkali Chlorides. *Jour. Chem. Soc. Abst.* 1899 p. 469, from *Jour. Amer. Chem. Soc.* 1899, p. 411-415.

Relations between the surface tension and the concentration of solutions of chlorides of Li, K and Na are established and illustrated by curves. The curve for NaCl lies about midway between those for K and Li salts, the surface tension being greater for a smaller molecular weight. If the concentrations be expressed in molecules per liter, the 3 curves become coincident. The curves show a slight convexity towards the axis of concentrations.



- 646.** 1899. FORCH, CARL. Ueber die Oberflächenspannungen wässriger Lösungen. *Wied. Ann.* Vol. 68, p. 801-816. Also see *Jour. Chem. Soc. Abst.* 1899, p. 640.

The author follows Traube's method of determining surface tension of aqueous solutions from the weight of falling drops (see No. 489) and adopts Traube's definition of *molecular elevation or depression of surface tension*, this being the excess of the surface tension of an aqueous solution over that of pure water or vice versa, divided by the concentration expressed in gramme equivalents. For NaCl,  $\text{Na}_2\text{SO}_4$ ,  $\text{NaNO}_3$ , for sugar and phosphoric acid, this value is nearly constant, and positive, i. e. the surface tension of the solution is greater than that of pure water. For  $\text{HNO}_3$  and fatty acids, there is depression which increases considerably with increasing dilution, reaching a maximum at a certain concentration for each acid, then decreases, hence is not a constant quantity as was supposed by Traube. Two sets of curves are constructed both with linear concentration as abscissae, one having as ordinates the above-mentioned excess of surface tensions, the other the same divided by the molecular concentration.

- 647.** 1899. JOHONNOTT, EDWIN S. JUN. Thickness of the Black Spot in Liquid Films. *Phil. Mag.* (5) Vol. 47, p. 501-522.

The thickness of the black film was measured by two optical methods. The author concludes that the thickness of the black film is not constant, and may vary from 6 to 40 micromillimeters. The film of a pure oleate solution may consist of two films, the thickness of the second being about one half of that of the first, the latter being about 12 micromillimeters. The addition of glycerin or  $\text{KNO}_3$  to a pure oleate solution prevents the appearance of the second black film. An atmosphere of  $\text{CO}_2$  thickens the black into a colored film and gradually decomposes it.

- 648.** 1899. GRIFFITHS, ALBERT. A Study of an Apparatus for the Determination of the Rate of Diffusion of Solids dissolved in Liquids. *Phil. Mag.* (5) Vol. 47, p. 530-539.

The apparatus used is a closed rectangular vessel divided into an upper and lower compartment which are in communication by a series of tubes of known area, the tubes projecting equally above and below the dividing wall. Each compartment has an inlet and an outlet tube. For heavier liquids, the vessel is first filled with water, that in the lower compartment is then displaced by the liquid. Diffusion takes place through the tubes. The possibilities of error are discussed, and the results quite agree with theory.

- 649.** 1899. RAYLEIGH, LORD. Investigations in Capillarity. *Phil. Mag.* (5) Vol. 48, p. 321-337.

The paper deals with the following subjects: (1) The size of drops; this is a critical examination of Tate's first law (see No. 281); (2) the liberation of gas from supersaturated solutions (see No. 340); (3) colliding jets (see No. 402); (4) the tension of contaminated water surfaces. In the latter chapter, experiments similar to those of Miss Pockels (see No. 572) are carried out and her results verified. The significance of her observations consists in the fact that the abrupt change in surface tension noticeable upon contaminated surfaces, indicates molecular distances which are thus measurable.

- 650.** 1900. DUTOIT, P. and FRIDERICH, LOUIS. Surface tension of organic liquids. *Comptes Rendus*, Vol. 130 (1900) p. 327-330. Also see *Jour. Chem. Soc. Abst.* Vol. II (1900) p. 194.

The temperature-coefficient in Ramsay and Shields's formula for the molecular surface energy  $K=2.121$  for non-associating liquids; see No. 576) was determined for a number of organic liquids. In abnormal liquids, the value of  $K$  varies with temperature; for normal liquids, it is not quite constant but varies within limits greater than was hitherto supposed.

- 651.** 1900. LINEBARGER, C. E. Surface tensions of mixtures of Sulphuric acid and Water, and the Molecular Mass of Sulphuric acid. *Jour. Amer. Chem. Soc.* 1900, p. 5-11. Also see *Jour. Chem. Soc. Abst.* 1900, Vol. II, p. 273 and *Chem. Centralblatt*, 1900, Vol. 1, p. 580.

By the aid of the apparatus previously described (see No. 611) the surface tension of aqueous  $\text{H}_2\text{SO}_4$  was determined at concentrations ranging from 2.65 to 95% and at temperatures between  $6^\circ$  and  $70^\circ\text{C}$ . It was found that the surface tension of either water or acid, especially of the latter, was raised by the addition of the other component. For the higher concentrations of  $\text{H}_2\text{SO}_4$  the influence of temperature is very slight, due probably to a high degree of polymerization.

- 652.** 1900. BARNES, JAMES. Conductivity, Specific Gravity and Surface Tension of aqueous solutions containing Potassium chloride and Potassium sulphate. *Jour. Chem. Soc. Abst.* 1900, Vol. II, p. 332; also see *Chem. Centralblatt*, 1900, Vol. I, p. 391 from *Trans. Nova Scot. Inst. Sci.* Vol. 10, p. 49-66.

The author found that the values for the conductivity, specific gravity and surface tension of mixed solutions of the above-named salts agree within the limits of experimental error with those calculated by means of McGregor's formula (see No. 639) from the corresponding properties of the separate solutions.

- 653.** 1900. BAKKER G. Theory of Capillarity. *Zschr. f. Phys. Chem.* Vol. 33, (1900) p. 477-499; also see *Jour. Chem. Soc. Abst.* (1900) Vol. II, p. 466.

"The author considers the usual treatment and derivation of the laws of capillarity to be unsatisfactory, and gives a different method for their derivation."

- 654.** 1900. PHILLIPS, C. E. S. A Surface Tension Lecture Experiment. *Nature*, Vol. 61, p. 481-582.

Water between two microscope cover glasses shows effect of surface tension. If the glasses are circular, they "set" in any position; if elliptical, or square, they "set" in one definite position, into which they return if displaced. Two circular disks, with water between, might be used, for example, to instal the moving system of a galvanometer.

- 655.** 1900. NANSEN, F. On Hydrometers and the Surface Tension of Liquids. In *The Norwegian North Polar Expedition*, 1893-1896. *Scientific Results*, 1900, Vol. 10, p. 61.

Referred to by R. H. Weber, *Ann. d. Physik* (5) Vol. 4, (1901) p. 706-719.

- 656.** 1900. BAKER, T. J. A Surface Tension Experiment. *Nature*, Vol. 62, p. 196-197.

This experiment refers to the formation of egg-shaped disks of water which form when a jet of water issuing from a vertical tube, strikes a horizontal disk about 7 mm. in diameter. Photographs of such waterfilms are shown for velocities varying from 4000 to 1000 cc per minute. The inner pressure is only 1 mm. of water above that outside.

This phenomenon has long been known, even for centuries. (HENRY BOURGET, *ibid.* p. 269.)

- 657.** 1900. TROUTON, F. T. The Creeping of Liquids, and Surface Tension of Mixtures. *Nature*, Vol. 62, p. 562.

The more volatile of two constituents of a mixture of liquids creeps in advance of the other constituent. The action is stopped when evaporation is prevented. Zinc surfaces especially promote creeping. The surface tensions of mixtures of liquids are as a rule less than the values calculated from the surface tension and the proportions of their constituents. Those of salt solutions increase with the number of gram equivalents of the salt present, practically irrespective of the nature of the salt, a fact first pointed out by Quincke.

- 658.** 1900. SMITH, S. W. J. On the Nature of Electrocapillary Phenomena. *Phil. Trans.* Vol. 193A (1900) p. 47-87.

A critical discussion of the Lippmann-Helmholtz theory of the capillary electrometer (see No. 343). Also see W. OSTWALD, *Phil. Mag.* (5) Vol. 22 (1886) p. 70; Vol. 27, (1889) p. 365-366; Vol. 29 (1890) p. 479-480; Vol. 30 (1890) p. 506-507; and J. BROWN, *Phil. Mag.* (5) Vol. 27 (1889) p. 384-392; Vol. 29, p. 376; Vol. 30, p. 170-171.

- 659.** 1900. VINCENT, GEORGES. Sur l'Epaisseur des Couches de Passage. *Ann. Chim. Phys.* (7) Vol. 19, p. 421-516.

On plates of glass, thin layers of silver were deposited, varying in thickness from 0 to 170 micromillimeters, and the electric conductivity for different thicknesses was determined. The results point to the existence of a double layer (*couches de passage*) of less conductivity, having a total thickness of 50 micromillimeters, the outer is in contact with air, the inner with the glass, between them being a homogeneous intermediary layer if the total thickness exceeds 50. The author claims that Quincke, in his silver film experiment (see No. 307) did not obtain the distance of molecular activity; what he obtained was the thickness of the above-stated double layer.

360. 1900. DÖRGE, O. Eine Studie über Seifenblasen. *Ann. d. Physik* (4) Vol. I, p. 1-16.

The first part of the paper consists in a theoretical application of Carnot's principle of the transformation of energy, to the case of soap bubbles receiving electrical energy which causes a change of inner pressure. In the second part, these variations are measured by the movement of a liquid index in a capillary tube, at its one end connected with the interior of the bubble, at its other end with a fixed volume. Upon charging the bubble electrically, the index moves in the direction demanded by the theory. Some quantitative measurements are made.

361. 1900. QUINCKE, G. Ueber die Dicke der Uebergangsschichten (couches de passage), und die Wirkungsweite der Molecularkräfte. *Ann. d. Physik*, Vol. II, p. 414-420.

Rejoinder to Vincent (see No. 659). Among other opinions he points out that films of alkali oleates do not present a homogeneous composition owing to hydrolysis, resulting in 3 layers each of unknown thickness, hence the thickness of such films is not a comparable quantity and does not permit calculation of the radius of the sphere of molecular action.

362. 1900. STEVENS, JAMES S. A Method for Measuring Surface Tension. *Amer. Jour. Science*, Vol. 160, p. 245-246.

In measuring surface tensions by the method of disk detachment (compare No. 538), two difficulties exist, viz. the tension by the balance cannot be added in continuous increments, and it is difficult to apply the pull exactly at the "center of inertia" of the body to be torn from the liquid surface. These difficulties the author obviates by counteracting the pull by means of a magnetic coil which receives a current capable of being gradually reduced by the insertion of a continuous resistance system.

363. 1900. MÜLFARTH, P. Ueber Absorption von Gasen an Glaspulver. *Ann. der Physik* (4) Vol. 3, p. 328-352.

The paper is introduced by a most detailed collection of literature on the absorption of gases by glass. With powdered glass, the author arrived at the following results: Notable quantities of  $\text{CO}_2$  are absorbed even by perfectly dry powdered glass, absorption increasing with decreasing temperature or with increasing pressure, in the latter case approximately obeying Henry's law, and being completed after 1 to 2 hours. Moisture retards absorption, but it is completed in 1 or 2 days, and the total absorbed quantities are about equal with dry or moist powder. The quantities absorbed are not even approximately as high as those recorded by Bunsen for glass threads (see No. 469). The gases  $\text{C}_2\text{H}_2$ ,  $\text{N}_2\text{O}$ ,  $\text{CO}_2$ ,  $\text{SO}_2$ ,  $\text{NH}_3$  are absorbed in increasing quantities in the order named. Bunsen's "capillary absorption" does not seem to hold good for powdered glass.

364. 1900. GRUNMACH, LEO. Experimentelle Bestimmung der Oberflächenspannung von Flüssigkeiten und geschmolzenen Metallen durch Messung der Wellenlänge der auf ihnen erzeugten Capillarwellen. *Ann. d. Physik*, Vol. 3, p. 660-671.

The surface tension of a liquid mass may be calculated from data obtained by the method of capillary waves or ripples (FARADAY, 1831; SCOTT RUSSELL, 1834; L. MATTHIËSEN, *Pogg. Ann.* 1868, Vol. 134, p. 167. *Wied. Ann.* 1887, Vol. 32, p. 626, and *ibid.* 1889, Vol. 38, p. 118; SIR W. THOMSON, *Phil. Mag.* 1871, Vol. 42, p. 868). The ripples are generated by means of tuning forks (Matthiessen); the specific gravity, the number of vibrations per second, and the wave-lengths determine the surface tension. Values thus obtained for water, alcohol, sugar solutions, etc. show close agreement with those obtained from measuring height of rise of the same liquids in capillary tubes. The same method was employed in determining surface tension of molten metals. The value for tin is considerably less than that obtained by Quincke and by Siedentopf (see No. 620).

365. 1900. SUTHERLAND, W. The Molecular Constitution of Water. *Phil. Mag.* (5) Vol. 50, p. 460-489.

The author investigates in detail the constitution of water on the basis of its thermal behavior; the compressibility of water and the dissociation of ice into water by pressure; the surface tension and the constitution of the surface film; the viscosity, latent heat of fusion, specific heat and latent heat of evaporation, etc. As a result of this exceedingly interesting study, the author names the vapor of water *hydrol*,  $\text{H}_2\text{O}$ ; ice is *trihydrol* ( $\text{H}_2\text{O}$ )<sub>3</sub> and liquid water at ordinary temperatures is a mixture of *trihydrol* and *dihydrol* ( $\text{H}_2\text{O}$ )<sub>2</sub> in varying proportions. Probably at its critical temperature, liquid water is practically pure *dihydrol*. The polymerization of hydrol is only a special case of a general tendency of oxygen compounds, both organic and metallic, to polymerize.



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